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U. S. ARMY

No. 33

PONTON MANUAL

1917

WASHINGTON
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INTRODUCTION.

In 1868 a board of officers of the Corps of Engineers, consisting of Lieut. Col. J. C. Duane, Maj. H. L. Abbot, and Maj. William E. Merrill, was convened to consider and report upon the ponton equipage of the United States Army. This board submitted its report on June 30, 1869, and its recommendations were adopted November 15, 1869. The following introduction to the board's report gives a brief history of the ponton equipage of our service and the salient reasons for the selection of the system adopted:

Previous to the Mexican War no attempt was made to organize a bridge equipage in our service. During this war two complete trains of india-rubber pontons were constructed and sent into the field. At its close these trains were sent to West Point, where they were used for the instruction of cadets and engineer troops. A full description of this equipage is given in the "Professional Paper, Corps of Engineers, No. 4."

It soon became evident that india rubber was not at all adapted to the construction of pontons—

First. From the perishable nature of the material. The cylinders are formed of alternate layers of canvas and india rubber. The sulphur used in the process of vulcanization generates sulphuric acid, which soon destroys the fabric of the cloth.

Second. The extreme elasticity of this species of support gives to the bridge a rocking and oscillating motion so violent as to render it unsafe for the passage of animals.

Third. The most serious objection, however, is that a puncture, either above or below the water line, is equally fatal to the cylinder. Hence, a single sharpshooter from a rifle pit on the enemy's side of the stream can destroy these pontons as fast as they are launched.

In the autumn of 1858 the india rubber pontons having become entirely unserviceable, experiments were made to determine the composition of a bridge equipage that should be adapted to our service. In conducting these experiments the following fundamental rules were kept constantly in view:

First. The mobility of the train must be such as to enable it to keep pace with all the movements of the column to which it is attached.

Second. The train should furnish the means of ferrying troops promptly and safely, as in the case of disembarkations and the passage of a river by force.

Third. It should furnish the means of constructing a bridge capable of passing an army with all its trains over the largest and most rapid rivers with safety and without delay.

Now, under the most favorable circumstances, it is very difficult to reconcile the first and third of these rules when but one species of ponton is employed. In this country it is impossible. The immense trains with which our armies are unavoidably encumbered, the long marches to be made, and the numerous wide and rapid rivers to be crossed, demand an equipage of the most substantial character. On the other hand, the extended expeditions of light columns, which necessarily attend our military operations, require a train light enough to keep pace with the most rapid cavalry movements.

Hence we require both a (1) reserve and (2) advance-guard train.

The experiments above named included the trial of samples of the bridge equipages used by those European armies most experienced in the art of military bridge building.

Pontons were constructed after the models of the French bateau, the Austrian sectional ponton, and the Russian canvas boat.

rugated-iron boats were procured, corresponding as nearly in form and dimensions to the French and Austrian boats as the nature of the material would permit. A number of Birago trestles were also constructed. All of the above material, with the exception of the iron boats, was prepared by the enlisted men of Company A, Engineers.

The bridges formed of this material were exposed as much as possible to the action of heavy loads, storms, the tide, and floating ice. The material was also packed on carriages of various patterns in order to ascertain the best form, both of bridge material and of carriage for transportation.

The selection of the French, Russian, and Austrian trains for these experiments was made after a careful study of the various equipages used at present by the armies of Europe. These three nations alone appeared to have definitely settled on their systems, and this after much experience and thorough research.

The Prussians and Spaniards were seeking for substitutes for their bridges, which had proved unsatisfactory. The Sardinians had adopted a plan inferior to that of the Austrians, though similar in some respects. The English tin ponton had too many of the defects of the india rubber to answer our purposes.

After experimenting for two years with the above-mentioned material, the following conclusions were reached: The French ponton is superior to the Austrian in simplicity and stiffness; as a ferryboat it will transport more troops and is more easily managed; in the bridge its superiority is marked. With the French equipage the corresponding balks of the adjacent bays lap each other about 6 feet, and are firmly lashed together and to both gunwales of the ponton, which greatly increases the strength and stiffness of the roadway; while with the Austrian, the balks must meet on a sill directly over the axis of the boat. The bays thus hinging on this sill full play is allowed to the horizontal and vertical oscillation to which floating bridges are subject.

As to land transportation, the French train requires fewer carriages to transport the same length of bridge than the Austrian, since for each section of the latter ponton a separate vehicle is necessary. The length of the two carriages does not differ materially, this being determined by the length of the balks.

These considerations led to the adoption of the French ponton.

The next question was, What material should be employed in its construction? Lifeboats having been successfully made in this country out of corrugated iron, it was presumed that this material could be used with equal advantage in the present case. The first boat, made of the same thickness of metal as the largest class lifeboat, proved to be deficient in stiffness when placed in the bridge. The corrugations, running from bow to stern, diminished the power of the sides to resist the vertical strain caused by the weight of the roadway on the gunwales. To remedy this defect, it was proposed to line the boat amidships with iron corrugated vertically or to introduce strong iron ribs.

These expedients, though they would have increased the weight beyond that of the wooden ponton, might have been successful, but they were not attempted, as the boat failed in other respects. In fact, it would not bear land transportation; as in traveling over a rough road the joints open, either the rivets or sheet iron giving way. When in the bridge, if the boat grounds on an uneven or rocky botom, a hole is frequently punched through it, and such injuries can ot be repaired in the field. The wooden ponton is not only much less iable to such accidents, but can be readily repaired when they do ccur.

Previous to the Battle of Gettysburg, a ponton bridge over the Potomac at Harpers Ferry was destroyed, the pontons being scuttled and set adrift above the rapids. About three weeks after, the water having fallen, the boats were recovered, repaired with pieces of hardbread boxes obtained from the commissary, and used in constructing a bridge at Berlin, over which the entire army passed into Virginia.

With regard to the canvas boat, it soon became apparent that it was precisely what we required for our advance-guard train. It is light, simple, strong, easily repaired, and when packed can safely be transported with the superstructure of the bridge as rapidly as any column of troops can move. A strong argument in favor of its adoption was that it had been used successfully by the Russians for more than a hundred years, under every variety of circumstances likely to occur in this country.

The selection of the carriage for transporting the bridge material was next taken up. The French ponton wagon is not adapted to our rough roads. The wheels are too small and can not be increased in diameter without raising the load too high above the ground.

A carriage was finally devised on the principle of the four-horse truck used in the city of New York. By means of the horizontal fifth wheel over the front axle, and of an inclined wagon bed, forward wheels of the requisite size were enabled to reverse completely under the load, thus allowing the carriage to turn in a short space. This construction is absolutely necessary when so long-geared wagons travel over a crooked road.

For the chess wagons and canvas train, a similar wagon would, without doubt, have answered the purpose perfectly, so far as transportation was concerned; but the ordinary baggage wagon of the Quartermaster Department, with some modifications, was used on account of the facility with which it could be obtained and the readiness with which spare parts could be procured for repairs in the field.

The Birago trestle, which had been recently adopted by most of the European nations, was also thoroughly tested; and, the result proving favorable, it was proposed to employ it in connection with the pontons of both trains.

From the information gained by these experiments there resulted the system of bridge equipage adopted at the commencement of the late war. During the winter of 1861–62, five trains were constructed, each composed of 34 pontons and 8 trestles—the pontons being nearly of the same form and dimensions as the French bateau. The frame was somewhat different, the ribs being entire and strongly ironed, and the ironing stronger throughout. The stern was provided with a locker. There were also other alterations in the details of construction. The balks were stronger, and the Birago trestle was modified by substituting built beams instead of solid timber for the trestle caps and balks.

At the same time several canvas trains were organized. In constructing the ponton frame, the dimensions and form of the Russian boat were exactly retained. The scantling for the frame was considerably lighter, but being strongly braced and ironed, the strength was about the same. One train was composed of canvas boats and trestles, being, in truth, a trestle train with auxiliary pontons to be used only where the depth of water or muddy bottom prevent the use of trestles.

In the month of February, 1862, a ponton bridge, composed of about 60 boats of the reserve train, was thrown across the Potomac at Harpers Ferry. The river was then a perfect torrent, the water being 15 feet above the summer level and filled with driftwood and floating ice. The greatest difficulty was experienced in pulling the pontons into position, and it was necessary to make use of ship anchors and chain cables to hold them in place. Notwithstanding these unfavorable circumstances, the bridge was completed in about eight hours, and the corps commanded by Gen. Banks, with all its trains and artillery, passed over it without accident or delay.

Several of these trains accompanied the Army in the Peninsular campaign. The pontons were used in discharging quartermaster and commissary stores at Ship Point, in disembarking Gen. Franklin's command at West Point, and in constructing bridges over Hampton Creek, the streams in front of Yorktown, and the upper Chickahominy. Finally a bridge was built over the lower Chickahominy, about 2,000 feet along, over which nearly the whole Army of the

Potomac with its immense trains, artillery, and cavalry passed with promptness and safety.

After the army had passed, the bridge was dismantled and the balks, chess, etc., packed into the pontons which were formed into rafts and towed by steamers to Washington. The bridge trains were next transported to Harpers Ferry where a bridge was constructed a second time, but under entirely different circumstances from that built during the previous winter. The water was now not deep enough, and as it continued to subside shortly after the bridge was laid, many of the pontons grounded on a very uneven and rocky bottom. Some of them were completely out of water, yet the heavy trains continued to move over the bridge without seriously injuring them, and when the water rose most of them floated as well as ever.

Discovering in this way that the boats were much stronger than we had supposed, we were enabled to improve the method of bridging tidal streams.

It had formerly been considered necessary to build out to low-water mark with trestles so that the ponton should always be afloat. The bridge is now commenced at high-water mark, building with pontons alone. As the water subsides, the pontons nearest shore ground successively, forming a gentle ramp from the abutment to the floating portion of the bridge instead of making the descent in 20 feet, as formerly. This method, of course, applies only to wooden pontons and to cases where the bottom is favorable.

During the Fredericksburg campaign it became necessary to force the passage of the Rappahannock. The enemy having entrenched themselves on the bank, prevented for some time the construction of the bridge, until at length troops were embarked in the pontons and ferried across, where they stormed the rifle pits and held them until the bridge was completed.

During the year 1863 the ponton trains accompanied the army in all its marches backward and forward through Virginia, frequently bridging the Potomac, Rapidan, and Rappahannock. In the latter stream the bridges remained in position all winter and, notwithstanding the frequent floods and the quantity of ice formed, but few interruptions occurred upon these thoroughfares.

During the campaign of 1864 trains composed of 14 pontons and 2 trestles accompanied each of the three army corps of the Army of the Potomac. These trains attended their corps in the long march from Culpeper to the James River, and although the roads were frequently very bad, in no instance did they delay the march of the troops or arrive late when a bridge was to be laid.

The headquarters train was followed by a canvas train, which, when a crossing was to be made by surprise, was sent forward with the cavalry, who covered the construction of the bridge and held the position till the main body arrived.

On reaching the James River a bridge was laid opposite Charles City Courthouse about 2,000 feet in length. The water was so deep and rapid that the pontons could not be held by their own anchors, and it was found necessary to attach their cables to schooners anchored above and below the bridge.

Thus the wooden ponton train, through four years of war during which the bridges constructed were without parallel in number and magnitude, amply fulfilled all the requisites of a good bridge equipage. The frequent crossing of the Chickahominy, Potomac, and James Rivers proved that, even under the most unfavorable circumstances, it could furnish a bridge capable of passing a large army with its heaviest trains over wide and rapid streams with safety and dispatch.

Its capabilities in ferrying troops were shown at Ship Point, West Point, and Fredericksburg; and of the mobility of the equipage there was abundant proof in the long marches during the last two years of the war.

The canvas equipage also was perfectly successful as an advance-guard train. In the cavalry raids it was always able to keep pace with the columns; and, although they frequently marched hundreds of miles, it was invariably ready to furnish a prompt and secure means of crossing all the streams on their route. It also often furnished bridges for the heavy trains of the army over streams of moderate width and rapidity.

The only part of the bridge equipage which did not realize all our expectations was the Birago trestle.

As already stated, a train was organized early in the war on the Austrian principle, in which the trestle is the main dependence, the pontoon being merely auxiliary. It was supposed that many streams would be encountered which could be bridged best with trestles alone, but none such were met with. In fact when a stream is more than 2 feet deep, a ponton bridge may be laid; when less than that depth, if the bottom is hard, it may be forded and no bridge is required; should the bottom be soft, the trestle legs will usually settle so as to render the bridge unsafe. As it was not deemed advisable to transport with the army a train which could only be used in exceptional cases, this description of equipage was abandoned. The trestle was, however, very useful as an auxiliary, especially with the canvas train; for as these boats when in the bridge should never be allowed to touch the bottom, it is frequently necessary to build out several bays from the shore before sufficient depth of water can be obtained to float the ponton—and for this purpose nothing could be better than the Birago trestle, which is also equally useful for a similar purpose with the reserve train when the river bottom is rough near the shore.

The canvas train was extensively used by the western army, and with such success that it was proposed to employ it exclusively. Experience, however, in the East has clearly proved that this train can not fulfill all that is required of the bridge equipage of a large army. The bridges of the Potomac and James Rivers could not have been built with canvas boats, which will not resist ice and driftwood; neither are they suited to the disembarkation of troops or the passage of a river by force.

Experience would therefore lead us to concur with Gen. Barnard in his remarks on this subject, viz:

"The numerous proposers of 'flying' bridges forget that if a military bridge is intended to be carried with an army it is also intended to carry an army, its columns of men, its cavalry, its countless heavy wagons, and its ponderous artillery. It must carry all these, and it must do it with certainty and safety, even though a demoralized corps should rush upon it in throngs.

"No makeshift expedient, no 'ingenious' invention not tested by severe experiment, no light affair of which the chief merit alleged is that it is light, will be likely to do what is required and what the French ponton has so often done."

Experience with the ponton equipage since 1869 has indicated no necessity for any radical modification of the adopted system. The Birago trestle has been replaced by one of stronger design, and minor modifications in the carriages and parts of the equipage have been made where such modification has been shown by experience to be desirable. The provision of a standard equipment for engineer troops has permitted a material reduction in the list of tools and supplies for the ponton tool wagon, the addition thereto of the essential parts of the load of the traveling forge, and the omission of the latter.

Experiments have been conducted with a view to the substitution of steel for wood in the construction of boats for the heavy equipage, but the conclusions drawn therefrom do not warrant such a change as long as suitable materials for the construction of wooden boats are readily available. Experiments have also been made with a view to the introduction of a sectional boat which would permit of the construction of both heavy and light bridges and thus avoid the necessity of two types of equipage, but thus far these experiments have given no justification for the adoption of such a system. The increasing difficulty of obtaining suitable wood, and the improvements in metal construction, have led many nations to use metal pontons. Except for water-tightness, metal boats have no advantages

wooden ones, while their disadvantages are numerous. Th
mely light metal boats used with European cavalry are considere
ve no advantages over our canvas pontons, if indeed they ar
ly good, and there is no question but that the existing advance
equipage will be able to follow the movements of the cavalr
ion. Our equipage is the result of the ripe experience gaine
e extensive operations of our Civil War and was adopted by
of veteran experts while the facts of the war were still fres
eir memories. Since then there have been no military operation
hich pontons have received any test approximating the one
in our Civil War nor have any basic improvements been made

CHAPTER 1.

FERRIES AND EXPEDIENTS FOR THE PASSAGE OF RIVERS.

1. **General conditions.**—When an army in the field finds its march interrupted by a river, it may effect the passage of this obstacle either by fording, by passing on ice, or by boats, rafts, ferries, or military bridges. As a principle the crossing of important streams should be effected by bridges; if these are constructed with bridge equipage, they should be replaced as soon as possible by other bridges, to permit the equipage to accompany the advance of the army.

2. **Reconnoissance.**—The selection of the place and means of crossing a river is determined by a reconnoissance, which should be as detailed and extensive as circumstances will permit, and in which the officer in charge of preparing the passage should take part. Tactical considerations will ordinarily determine the limits within which the crossing must be made, but within these limits technical considerations govern the selection.

PASSAGE BY FORDS.

3. A river with a moderate current may be forded by infantry when its depth does not exceed 3.5 feet and by cavalry when its depth is not greater than about 4.5 feet. Artillery and wagons can cross a ford about 3 feet deep, but if the contents of the wagons are to be kept dry the maximum allowable depth is about 2.5 feet.

4. Fords are unreliable stream crossings, and should be replaced by bridges at the earliest opportunity. A rise in a river may render it unfordable or a ford may be worn out by an army before the completion of its passage. Fords are ordinarily used only by small bodies of troops without bridge equipage, although there are instances where whole armies have crossed by them.

5. The requisites for a good ford are that the banks be low, but not marshy; that the water attain its greatest depth gradually; that the current be moderate and the stream not subject to sudden freshets; and that the bottom be even, hard, and tenacious.

6. Mountain streams are generally more frequently fordable than alluvial ones, but are also more liable to freshets, and the bottoms are frequently covered with large stones, rendering the passage of wheeled transportation nearly or quite impracticable. In level countries the case is often still worse, the bottom, either of mud or quicksand, being impassable both for men and carriages. Sometimes the bottom is composed of fine sand which is hard enough, but which by the action of the hoofs of animals is stirred up and washed away, increasing the depth until the stream becomes unfordable. The best bottom is coarse gravel.

7. **Location of fords.**—Fords are usually found in the wider and more rapid parts of the river. A stream not fordable at right angles to the current may be fordable in an oblique direction between bends. Tracks leading into the water and reappearing on the opopsite bank indicate a ford. A line of water differing in color from the water above and below it and extending unbroken and usually obliquely across the stream frequently indicates a ford. If the line of color be broken, the gaps are generally deep channels which are not fordable.

8. The position of fords may be determined by sending a number of mounted men across wherever there is a probability of the river being shallow enough. The most certain method is to float down the

stream in a boat, keeping it in the swiftest part of the current, where the stream is usually the deepest. Over the stern a sounding line or pole is held at the proper depth; when this touches bottom the river is sounded across, either directly, obliquely, or both. When the ford is discovered both ends should be marked and the prominent landmarks noted so that it can be easily recognized and a gauge should be established in order that any variation in depth may be ascertained.

9. Fords delay columns, unless the troops can cross at several places at once. Additional fords should, therefore, be sought despite the denial of their existence by the inhabitants, especially in hostile country.

10. **Preparation of fords.**—Dangerous fords should be clearly marked by strong pickets driven into the river bed above and below the ford, their heads being connected by a strong rope which is securely anchored to the shores. Lanterns or torches are placed as range and beacon lights to mark the ford at night.

11. After a freshet the ford should be reexamined lest some alteration may have taken place in the bed of the river.

12. A river which is not fordable may sometimes be rendered so when the only obstacle is too great a depth of water over an extent of 8 or 10 yards by filling in this portion of its bed with fascines loaded with stones or with stone and gravel. When the water is sluggish or muddy a ford may be improved by covering the bottom with weighted bundles of coarse grass, rushes, or brush. The same method is used to improve approaches through soft sand or mud.

13. **The passage.**—An officer with a suitable detail of troops is placed in charge of the passage. It is his duty to see that the ford is kept marked, repairs promptly made, men washed away rescued, and the passage made in such order and formation as will cause the least damage to the ford. He will communicate with the commander of each regiment or smaller independent unit before its passage, and his instructions for the passage must be strictly observed.

14. Infantry pass in column of squads, rifles slung, the men in each rank holding to each other. The distances between squads are made sufficient to prevent damming the stream. The men incline their bodies toward the current, fix their eyes on the opposite bank, and do not look at the water. Passages have been effected in swift water, waist deep, by stretching a rope across the stream to give a handhold for the upstream man in each squad.

15. Artillery and wagons pass in column with distances sufficient to prevent damming the stream.

16. Cavalry pass in column, usually of twos. The horses are taken directly across without allowing them to stop to drink.

17. In all arms the formation for passage is taken up at least 100 yards before reaching the ford and is maintained for at least 100 yards after passage. The commander of each unit sees that his men take the required formation.

18. If required boats are used during the passage, some being stationed below the ford to assist men who may be carried down by the current. When boats are lacking, this duty may be performed by mounted men, and a life line may be stretched across supported on casks or other floats.

19. **Destruction of fords.**—In a retreat it is frequently advisable to destroy a ford after having used it. This destruction may be effected by digging trenches across the ford parallel to the current; by exploding charges of explosive on the bottom of the deepest part; by filling the deepest part with harrows, teeth up, or with planks filled with spikes, crow's-feet, barbed wire, or other obstructions; by scarping the banks, etc.

PASSAGE ON ICE.

20. Crossing a river on ice should never be counted upon in a plan of campaign and should be made only with great circumspection. A slight change of temperature may not only suddenly destroy this natural bridge, but the floating ice may render the river impassable by any method for a considerable time.

21. The bearing power of ice varies greatly. Fresh sound ice in floating contact with the water has much greater strength than rotten or arched ice. Ice is generally thicker near the banks than in midstream. Before attempting a passage, the thickness of the ice across the entire stream should be tested by cutting frequent holes which will serve also to indicate the quality of the ice and to detect and arching. New sound ice in floating contact with water will bear the following loads: 3 inches, small groups of men; 4.5 inches, cavalry in small groups; 7 inches, wagons and field guns; 9 to 12 inches, the heaviest loads with an army.

22. **Expedients.**—Two tracks of planks laid on the ice for the carriage wheels to run on may be employed when there is any doubt as to its strength, or the wagons may be transformed into sleds by fastening planks under the wheels. A better foothold for the horses is provided by a slight coat of sand, earth, cinders, straw, or other suitable covering for the ice.

23. The thickness of ice may be increased, when the temperature is low enough, by slightly flooding its surface, the water being retained by a light earthern dam. The thickened ice must form a belt at least three times the width of the roadway. Six or eight inches of straw, twigs, or manure, laid over a belt three times the width of the roadway and well flooded will, when frozen, often insure a safe passage.

24. When the river is frozen on each side, but open in the middle in consequence of the velocity of the current, a boom stretched across the open space will often check the velocity sufficiently to cause the water to freeze. Trees or other obstructions may serve the same purpose. Cakes, of ice floated against the obstruction hasten freezing.

25. **Passage.**—The officer in charge of the passage is responsible that the means and method of passage are such as to give the greatest degree of safety. He will advise commanders of regiments and smaller independent units of the provisions to be made for passage. His instructions for the passage will be strictly complied with. Care must be taken not to let the men crowd upon the ice.

PASSAGE BY BOATS.

26. The passage of nonfordable rivers is ordinarily effected by military bridges or by ferries. There are times, however, when the enemy by lightly holding the opposite bank at the desired point of crossing, can effectually prevent passage by either of these means so long as he holds his position. In such cases it is necessary to force a passage by transporting a body of troops across the stream to drive away the enemy so that a bridge or ferry can be constructed, for it is practically impossible to construct a bridge or ferry under short-range fire, even when favored by fog or darkness. The first step in the construction of any bridge, where opposition is expected, is the crossing of a covering detachment. In order that the covering detachment may not be overwhelmed, the bridge must be constructed with the least delay. In addition to pontons it is desirable to use other boats for crossing the covering detachment as far as practicable, some pontons being reserved to commence the construction of the bridge.

27. The point of passage being decided upon, all available boats will be collected. A small stream which is sufficient to float the boats, affords concealment for the work of preparation, and enters the main stream near the point of passage is most favorable for assembling and loading the boats preparatory to entering the main stream. The landing on the opposite shore should be farther downstream than the point of embarkation, as the loaded boats will drift with the current.

28. The knowledge that boats are being assembled at any spot will cause it to be carefully watched by the enemy. It may, therefore, be necessary to carry the boats by hand a sufficient distance to prevent the sound of wagons being heard. This was done at Fredericksburg, where 20 heavy pontons were transported nearly a mile in three hours and launched without discovery. Thirty men were required for each boat. The boats were turned upside down

and carried on poles about 10 feet long, which were placed under the gunwales. These poles were supported by the hands, the arms extended at full length. Boats may be carried two or three hundred yards in this manner without resting. In smooth grassland or through mud a ponton may be easily moved by dragropes, using either men or animals. For long distances a temporary sled, made of two stout planks with suitable crosspieces, should be employed. A ponton may be dragged many miles in this manner. Canvas pontons may be carried on the shoulder long distances by 10 men, but the difficulty of rowing makes them less suitable for forcing a passage than the wooden boats.

29. **Capacity of boats.**—When transporting troops, a ponton should not be loaded to less than 1 foot of freeboard. The normal capacity of a heavy ponton is 30 men in addition to the crew and that of a canvas ponton is 20 men in addition to the crew. These numbers may be increased in quiet water or narrow streams.[1] The safe loads of other boats are determined by actual tests. The number of men and the crew carried should then be marked on the stern of the boat. The available buoyancy of a boat for use in a bridge may be similarly tested, allowing 160 pounds for unarmed men without equipments and 200 pounds for men fully armed and equipped.

30. The boats are arranged along the shore according to size and numbered, the smallest boats being upstream. The boats are moored by the stern to the bank not less than 12 yards apart, and the pontoniers take their prescribed positions. Two extra oars are supplied to replace any broken or lost. To shove off the boats a detail is provided, which remains behind when the start is made. The flotilla is now ready for the troops to embark.

31. **Passage.**—The passage is effected under the charge of an officer, who is assisted by the necessary details. The instructions of the officer in charge and of his assistants will be strictly complied with. The troops will be instructed to preserve silence during the passage; to remain steady, no matter how much the boat may rock; not to crowd the oarsmen; and under no circumstances to open fire while in the boats.

32. The troops are divided into detachments, assigned to boats, and given the necessary instructions, either at the halting place or, if time presses, on the march. Each detachment is provided with the number and location of its boat and, if possible, a guide. Due regard will be had for the preservation of tactical units in assigning detachments to boats.

33. The men enter by the stern and advance as near the bow oarsman as the sweep of his oar will permit, taking their places alternately against the right and left gunwale. When the gunwales are full any intermediate space is filled. The men next to the gunwales sit on them, while the others squat down in the boat. If the boat grounds in loading, the detail on shore pushes it farther out, and the remainder of the detachment enters by wading. As soon as the boat is full the crew is quietly brought to the position of OARS. When pontons are used their bottoms are floored with chess.

If canvas pontons are used, they must not be allowed to ground. The detachment enters by wading and sits or kneels on the chess laid in the bottom of the ponton.

34. As soon as the chief of the flotilla ascertains that all is in readiness he gives the signal to advance, usually embarking himself in the upstream boat. This boat is always the guide, and every exertion is made to keep it perpendicular to the thread of the current, unless it must be headed upstream in order to reach a good landing place. The proper intervals are carefully preserved by the other boats, and as soon as any boat touches the opposite shore the troops disembark, passing over the bow. If a boat grounds in the passage, its chief causes some or all of his oarsmen to bring their oars to the position of OARS, to transfer them to the nearest soldiers, and to jump overboard and disengage the boat. When no further progress can be made the troops disembark and wade ashore.

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[1] At Fredericksburg 50 men were ferried in each heavy ponton.

As soon as the boats are unloaded the chief of the flotilla causes it to go back for another detachment. Under no pretext whatsoever will any one, except officers bearing dispatches, be carried on the return trip.

35. **Passage of cavalry.**—Cavalry are rarely crossed in boats if the passage is opposed. The preparation of the boats is the same as for infantry, except that fewer oarsmen are required and the flooring of chess may be omitted in the wooden pontons. The horse equipments are placed in the boat. The cavalrymen take post on each side, leading their horses by the bridles. The boat is pushed off and taken straight across, the horses swimming by the sides. The cavalrymen hold their horses' heads well up, supporting them with both the bridle and the hand. As soon as the horses strike bottom they are led ashore successively, beginning with the one next to the bow.

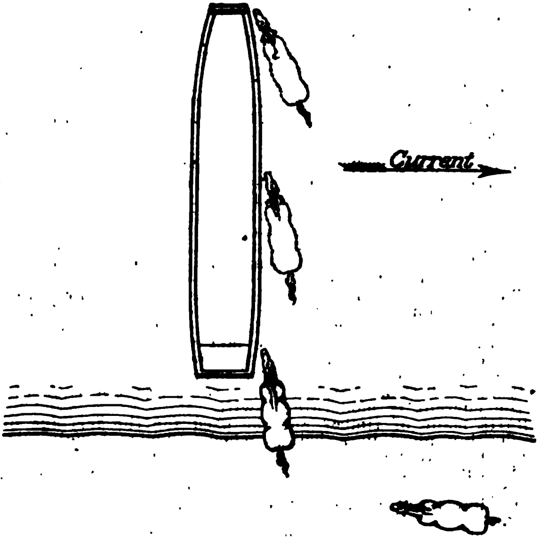


Fig. 1.—Horses swimming.

If possible, a landing place is selected where the bank slopes gently to the water. When there is little or no current, the horses can be swum on both sides; if there is much current, the horses can be swum on the downstream side only. When pontons are employed six horses can be swum on both sides, or three only on the downstream side, according to the strength of current.

PASSAGE BY RAFTS.

36. The transportation of troops and material over water areas may be required at times for purposes other than that of forcing a passage. In such cases boats will rarely be used exclusively, as it will generally be found more advantageous to build rafts from the boats or other material and use these in whole or in part for transportation purposes.

Under conditions where opposition by the enemy is not feared and a crossing by surprise is not contemplated, preparation for crossing a river can be conducted with greater deliberation; boats are collected and rafts constructed either from the boats or from casks, lumber, and other suitable material, and where the banks of the river are too steep to afford satisfactory landing places they can be prepared by digging.

If boats are used either alone or in conjunction with rafts, the manner of effecting the crossing with them is, in general, the same as when a passage must be forced, with the exception that for mounted troops it is preferable to cross the men without their horses, and then swim the latter in the manner shown in figure 1, or when boats of sufficient size are available, the horses may be actually carried across. In this case the horses should be placed crosswise facing alternately up and down stream, so that they will not be thrown down by the rolling of the boat.

When rafts are to be used in conjunction with boats to effect the crossing of a river, they should be placed downstream of the latter.

37. The passage of all arms may be facilitated by contructing a raft formed of two boats covered with a platform. Not only may artillery, cavalry, and trains be transported by this means but also infantry in much greater numbers than by using the boats separately. A good boat raft can be maneuvered by oars with nearly the same facility as a boat.

38. To construct a raft from five to seven beams of the same thickness are laid across the two boats, the interval between the boats being such as to allow the beams to extend about 2 feet beyond the outer gunwales. The beams are lashed to the boats and covered with planks, which are kept in place by two side rails laid directly over the outer beams and lashed down to them. The extreme planks are nailed down. The size of beams is regulated by the load and the interval between the boats.

39. The heavy pontons of the bridge equipage are well suited to the construction of rafts. The method of construction is shown in figure 2. A single bay of bridge is built, using seven balks a roadway bearers, spiking down the last two chess at each end, and securing the remainder of the floor by side rails. Each balk is lashed to both gunwales of each ponton. The light pontons can be similarly made into a raft, but such rafts are not easy to manage where the current is moderately swift.

40. Rafts made of timber may be used for the ferriage of troop or for floating piers in a bridge when other materials are not a hand, but it is to be observed that there are very few varieties o timber in this country which possess the requisite buoyancy whe green. Such rafts are secure against being sunk by hostile fire bu have the defects of small and decreasing buoyancy, great weight and bulk.

41. A timber raft should be at least 35 feet in length, and should be made from the largest and longest timber available in order t give it sufficient stability. Squaring the timbers will be wors than useless, but irregularities, such as branches and knots, should be trimmed off. The raft must be built in the water, preferably a a place where there is little current and where the bank slope gently to the stream. The timber is thrown into the water and moored to the shore at the place selected for building the raft After the position which the stick naturally assumes in the wate has been ascertained the end which is to be upstream when in th raft is drawn up on the shore and the lower side is beveled, so a to present less obstruction to the action of the current. The timbe is then arranged in the position it is to have in the raft, the butt alternately up and down stream and the upstream ends so arrange as to form a salient.

42. Assume that a raft is to be constructed of 20 logs, 47 fee long and averaging 12 inches in diameter. (Fig. 3.) The firs log is brought alongside the shore and the ends of two transom are spiked to it about 3 feet from each end. The log is the pushed off a little and a second log is brought up under the tran soms and in close contact with the first. The transoms are spike

to the second log, and so on for each of the remaining logs, care being taken to alternate the butts, to place the beveled ends upstream with the bevel underneath, and to have the transoms perpendicular to the logs. When the bank is too steep to admit of this method of construction the logs may be floated into their proper positions, lashed together, and the transoms spiked on. If the logs are of nearly the same size, the center of gravity will be near the center of the raft.

When a platform is to be constructed on the raft two additional transoms, about 8 inches wide by 6 inches thick, are fastened at equal distances from the center of gravity of the raft and at a distance apart equal to the width of the platform.

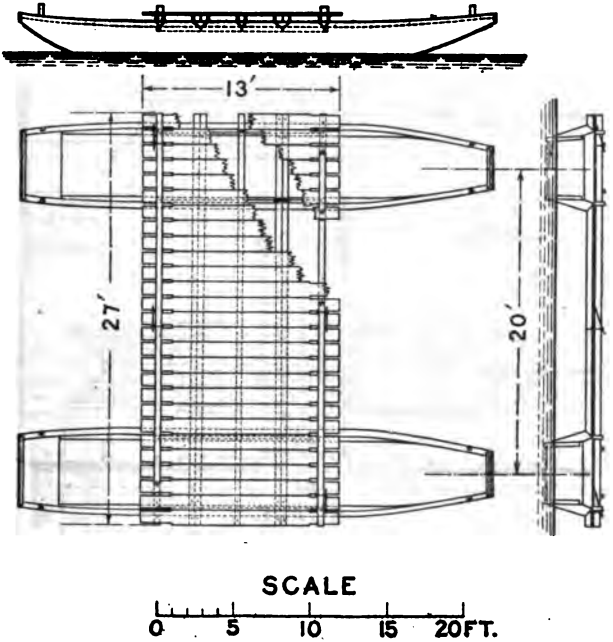


FIG. 2.—Raft from the equipage.

If square timber can not be had for transoms, saplings 7 or 8 inches in diameter may be used. Intermediate transoms are laid at distances apart depending on the strength of the planking used. The size of this platform must be regulated by the buoyancy of the raft. A single course of logs will not have sufficient buoyancy to sustain troops covering its entire surface. When necessary several courses of timber are employed, each perpendicular to that below it, and the whole firmly united with pins or lashings. All transoms should have a bearing on all the logs forming the raft. To effect this the larger logs should be adzed down and the smaller blocked up to the transom. Transoms may also be fastened with driftbolts or wooden pins, or each log may be lashed by passing a rope around it and the transom and twisting it tight with a rack stick.

When the raft is to be used in a bridge the two intermediate transoms are separated by a distance a little less than the length of the roadway planks and placed at equal distances from a point somewhat astern of the center of gravity of the raft, in order to counteract the downward pull of the cable on the upstream end. On these transoms three supports *d d d* are spiked to receive the balks. A piece of plank is nailed on the upstream end to prevent the cable from getting entangled in the raft.

43. When the logs are less than 35 feet in length the following method of construction is employed: The small ends of half the logs are beveled and a raft is formed similar to that described above, except that the butts are all downstream. The remaining logs are then brought butt to butt with those in the raft and fastened to them with iron clamps or dogs or by spiking a piece of plank across the two. A transom is spiked on the stern and the central transoms provided as in the preceding example. A transom *g* then placed a little forward of the center of gravity of the sec-on *a* and a transom *k* a little astern of the center of gravity the section *c*. The strong timbers *d d* extend over the four in-rior transoms. These timbers support the balks and distribute ie load over the entire raft, without tending to separate the sections.

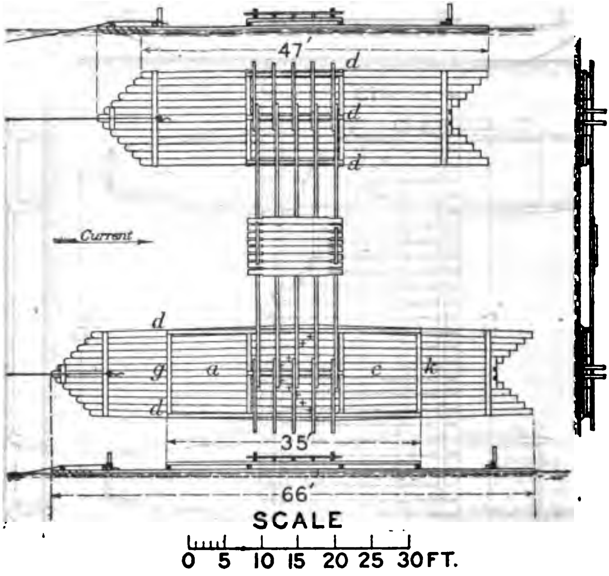


FIG. 3.—Raft with short and long timber.

44. Rafts are sometimes constructed for flying ferries in the form f a lozenge—the acute angles being about 55°—so that when two of the sides are parallel to the direction of the current the upstream side is in the most favorable position for the action of the current.

45. For use in a bridge a raft should be able to sustain at least 15,000 pounds. The same expedients are employed for the anchorage of rafts as for boats. It must, however, be borne in mind that a raft

offers a much greater obstruction to the current than a boat and that the strain on the cables is proportionally greater.

46. When barrels are available floating piers can be constructed therefrom and used either as supports for bridges or for the construction of rafts. A barrel completely submerged will support roughly eight times as many pounds as its total contents in United States gallons, but an allowance of from 20 to 25 per cent for safety must be made, as the barrels must not be completely submerged.

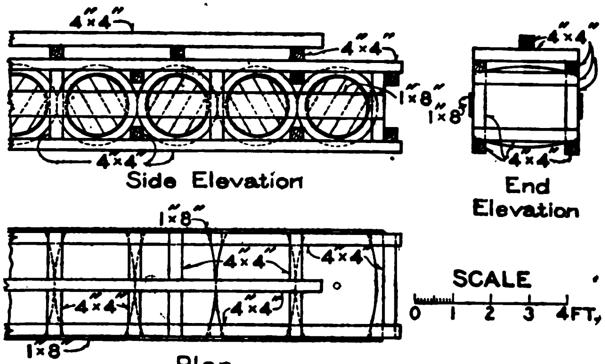


Fig. 4.—Complete frames.

47. Barrel piers may be constructed in either of two ways: By the use of frames or by the use of timbers and lashings. Figures 4 and 5 show two methods of construction using frames. These methods consist essentially in the construction of inverted crates for holding the barrels. The other way is shown in figures 6 to 9. In this the number of barrels is usually from five to seven, placed side by side. Two timbers called gunwales, of suitable length and 4 or 5 inches square or in diameter, are laid across the barrels near their heads. Two rope slings with an eye-splice at one end are then passed around the barrels to the ends of the gunwales, drawn tight and lashed as shown in the figure. Lashings of 1 inch circumference rope, about

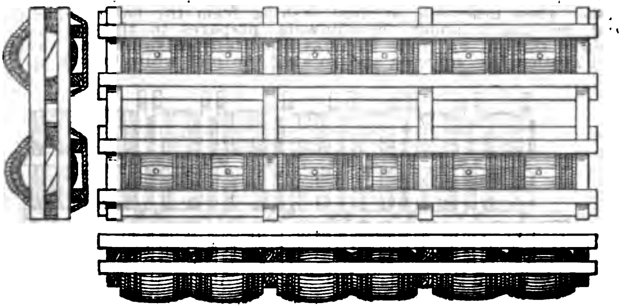


Fig. 5.—Lashed frames.

18 feet long, with an eye-splice at one end and a figure-of-eight kno about 18 inches from the eye, are used for lashing the gunwales an slings to the barrels in the following manner: The eye of a lashin is passed under each sling at each interval between barrels and th other end of the lashing is put through the eye and pulled taut, bot

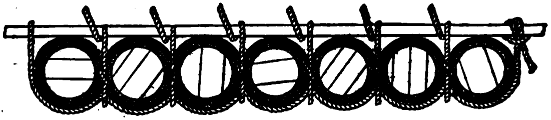


FIG. 6.—Lashed barrel piers.

sides being lashed simultaneously. Each lasher takes a turn to th left around the gunwale exactly over the eye of the lashing, pulls an holds the lashing taut and places its free end on the barrel to hi left. Each lasher then takes the coil of the lasher opposite hi from the barrel on his right and passes it around his own lashin

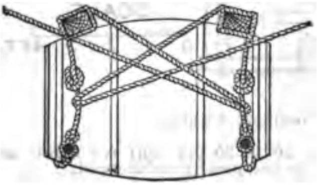


FIG. 7.—Lashed barrel piers.

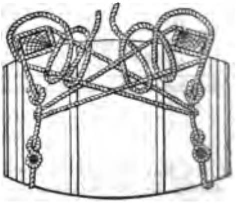


FIG. 8.—Lashed barrel piers.

and then places its free end on the barrel to his right, taking ca that the turn of the lashing is below the figure-of-eight knot. Eac lasher then takes his original lashing from the barrel on his le and, passing it under the gunwale, prepares to tighten up. Th lashers tighten up their lashings simultaneously, putting their le feet against the gunwale and rocking the pier while taking up slac

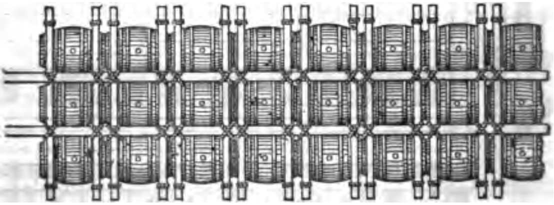


FIG. 9.—Lashed barrel raft.

Each lasher then takes a turn around the gunwale and two ha hitches around the two parts of his lashing close to the gunwal drawing the two parts close together and placing the free end of th rope between the barrels as shown in figure 8. Mooring cables a attached to a transom securely fastened across the gunwales. I launching, care must be taken not to injure or displace the ropes b chafing on the ground. After launching, rafts may be formed fro barrel piers in a manner similar to that described for boats.

48. The same rules apply to the passage of troops on rafts as in boats, attention being paid to the following circumstances: That rafts drift more than boats, consequently the landing on the opposite shore will be farther downstream; and that, as the embarkation is easier, there is more danger of overloading the raft and of confusion in embarking. Infantry enter by the flank and first occupy the middle line of the raft; a rank is then added alternately on the up and down stream sides until the raft is loaded. Artillery and heavy carriages are placed in the center and cavalry horses as when carried in boats.

Rafts possess these advantages over single boats, viz, the embarkation and landing of all arms is easier; they carry large numbers at each trip; they draw little water.

They can not, however, be navigated with the same facility as boats or directed with certainty on a fixed point when the stream is rapid, and in this case it is often impossible to bring them back against the current to the starting point.

Finally, the length of time required for their construction forbids their use when a passage is to be forced.

When the material for rafts is limited, the passage of a river can, in general, be executed more rapidly by means of ferries.

PASSAGES BY FERRIES.

49. The types of ferries commonly used are the rope ferry, the trail ferry, and the flying ferry, the latter two being also known as trail bridges and flying bridges.

50. **Rope ferry** (fig. 10).—The rope ferry, which is used in streams with sluggish currents, consists of a floating support, either a raft or a suitable boat. It is drawn by hand along a rope or chain stretched from bank to bank. To facilitate a grip on the rope a handle (fig. 11) may advantageously be employed. A rope ferry may be constructed by laying a cable or chain across the stream, anchoring its ends, and taking three or four turns around a windlass mounted on the side of the barge or raft used. An old wagon wheel may be utilized as a windlass. The safety of a ferry, specially when transporting animals, is materially increased by the construction of guardrails and end gates. Figure 12 shows two methods of constructing a flatboat suitable for a ferry.

51. **Trail and flying ferries.**—Where the current is as great as 3 feet per second it can be utilized to propel the raft. To accomplish this the sides of the raft are held at an angle of 55° to the current. Such ferries are known as trail ferries when fastened to a traveler on a cable stretched across the river, and as flying ferries when fastened to a fixed anchorage upstream. Although these ferries do not afford a continuous communication, yet they possess the following advantages:

They are readily established, even in the most rapid currents.

They require but little material for their construction.

They may be operated by very few men.

They permit the passage of troops of all arms, and of animals and vehicles.

The entrance to and exit from them is easy.

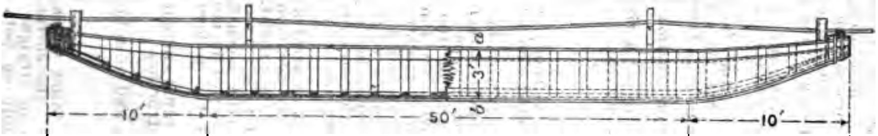
They do not interrupt navigation.

They are not liable to be injured by floating bodies which, either by accident or design, are carried downstream by the current.

52. Trail and flying ferries should be located in straight reaches of the river, and landing stages should be built on both banks. With these ferries it is sometimes difficult to reach the landing. In such cases a line buoyed in their track and attached to the landing may be used to pull them in, and poling may be resorted to in order to push them out into the current.

53. **Flying ferry.**—Flying ferries may be used in streams of any width. The upstream end of the ferry cable is made fast to an anchorage consisting of an anchored boat, a pile cluster, a tree on an island, or other fastening strong enough to stand the full pull on

Fig. 10.—Rope ferry.



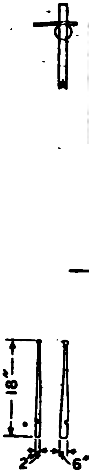


Fig. 11.—Rope grip.

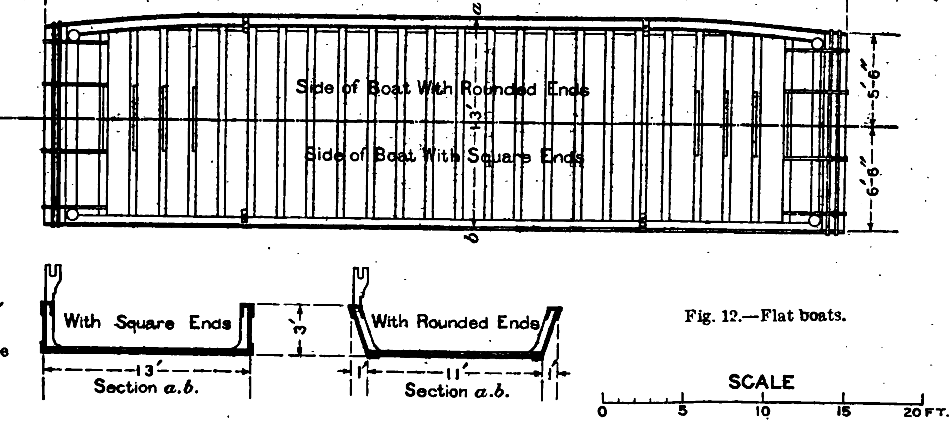


Fig. 12.—Flat boats.

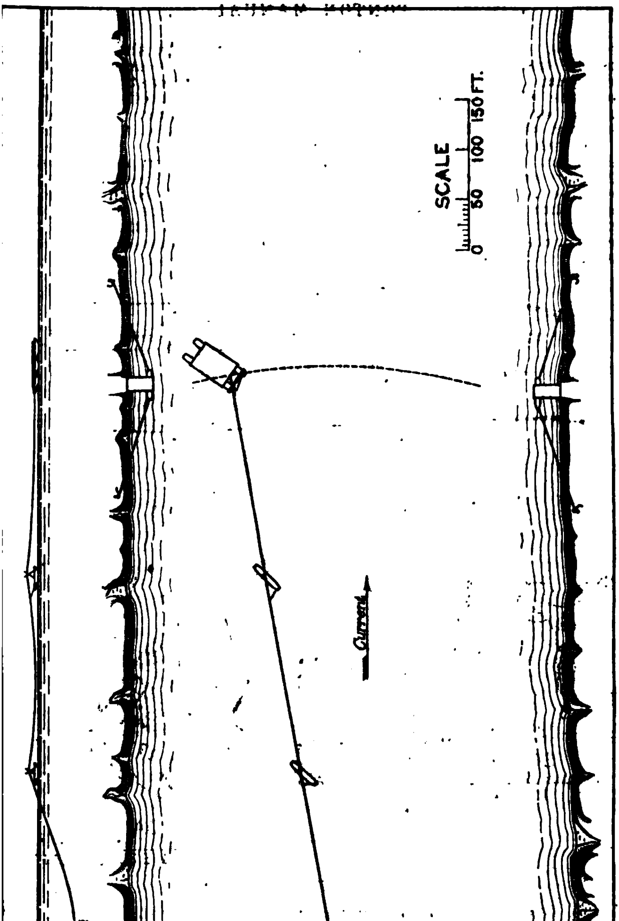


Fig. 13.—Flying ferry.

the cable. If the strongest current is nearer one shore, the anchor must be cast nearer the other shore; otherwise it should be cast in midstream. The length of the cable must be at least one and a half times the width of the river. The cable is supported at intervals by pontons or other floats (fig. 13). When an anchor is used, the first float should be as near it as possible without danger of tripping it; the others should be so arranged as to maintain the cable above the water. If found advisable, the cable may be supported above the water by an improvised staging on the floats. When so supported, the cable is connected with the bow of the float by a line of such length that the float is allowed to turn just enough to keep parallel with the raft. If no floats for the cable are used, it must be passed over a gallows frame on the raft to keep it from dragging in the water.

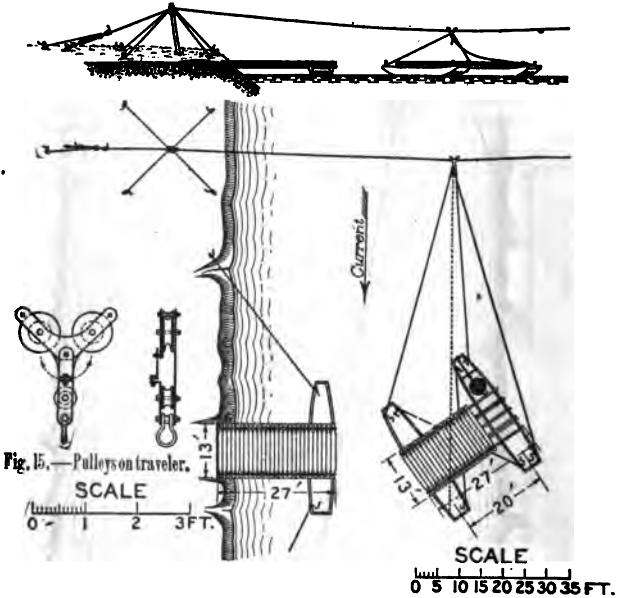


Fig. 15.—Pulleys on traveler.

FIG. 14.—Trail ferry.

54. A flying ferry is maneuvered in the following manner: The cable is made fast to the raft about the middle of the bow. The proper angle to the current, about 55°, may be obtained by the use of sweeps, or, better, by maneuvering ropes made fast to the main cable. The angle is gradually decreased on nearing the shore, until the way of the ferry is diminished sufficiently to prevent it from striking the landing with a shock.

After the ferry is attached to the cable, it is run from shore to shore once or twice until the anchors are firmly embedded, and the cable is stretched; the two landings are then constructed. The raft should be provided with spare cables and anchors ready for casting in case the mooring cable should part.

55. **Trail ferry.**—When the river is not more than 150 yards wide a sheer line may be used in place of the anchor and cable. The sheer line must be taut enough to keep it above the water, and if necessary it must be elevated at each shore by passing it over a frame as shown in figure 14. A capstan, or block and fall, should be provided to tighten the line from time to time as it stretches. Upon this line a pulley or traveler (fig. 15) is fixed so that it can run freely from shore to shore. A cable from the traveler is attached to the bow of the ferry. Maneuvering ropes are attached either to this cable or to the traveler. The ferry is maneuvered in the same manner as the flying ferry.

56. **Raft for trail and flying ferries from pontons.**—The raft for a trail ferry is the two-boat raft heretofore described. The usual form for the flying ferry is built of 6 pontons as shown in figure 16. Two pontons are lashed stern to stern, and to these a third, breaking joints. A second set similar to the above is placed at a distance of 20 feet, center to center, of the outside pontons. The two sets are connected by 6 balks *c*, over which 4 courses *d* are lashed; then 15 balks *e* are placed in a manner suitable for receiving the chess. The extreme chess are nailed down, and the outer courses secured by side rails.

57. **Other forms of raft for trail and flying ferries.**—Rafts of barrels, timber, or other material may be used in lieu of the ponton rafts just described. The most suitable raft for the purpose is one composed of two long, narrow, and deep boats, with nearly vertical sides. The best interval between the boats is such that the current will act on the sides of both boats through their entire length when they form the proper angle with the current. Barges or scows (fig. 17) are frequently used in place of rafts for ferries that have long or continuous service. Ramps which can be raised or lowered are convenient at each end of the raft; they may be made to balance one another by means of a pair of ropes, each running on a pair of pulleys supported by two props, one at each end of the platform of the raft. A ramp is lowered by men walking on it, thus at the same time raising the other.

58. **Chattanooga flying ferry.**—The flying ferry shown in figure 18 was used at Chattanooga during the Civil War for crossing men and vehicles over the Tennessee River. It could carry four six-mule teams and wagons, besides infantry and cavalry. The cable was attached to an island above and was supported on three floats. It was secured to the boat by a rope which was fastened by both ends to the end of the cable, and passed through snatch blocks at the bow and stern of the boat on the upstream side, and around a windlass at the middle. By turning the windlass any desired angle with the current, and therefore any desired velocity was readily obtained. Leeboards near bow and stern were used to catch the current and increase the velocity when required. One man could manage the ferry with ease.

59. **Anchorages.**—Where a single anchor is not sufficient, two or more anchors, with separate leads, may be attached to the same cable (fig. 19). Panniers of stone (fig. 20), picks lashed together, Chinese anchors (fig. 21), and similar expedients may be used in lieu of anchors. A rail bent into the form of a grapnel makes a powerful anchor. It may sometimes be advisable to use piles for an anchorage. In this case either single piles or clusters of piles are driven and the cable is attached as near the bottom as practicable. Anchorages out of the water are preferred, as they are more readily inspected and made secure. An island or a bridge pier makes an excellent anchorage. A very sharp bend may permit of an anchorage on one bank for a ferry just below the bend. In some cases the cable for a flying ferry may be anchored to the opposite bank. When this is done a second cable, anchored on the near bank, and four landing places, two on each bank, must, in general, be provided. When the raft reaches a landing place it is pulled up to the one above, whence it starts again, the second cable being used for the return trip.

60. **Expedients for ferriage.**—Canvas well stuffed with hay or other light material furnishes a support of considerable buoyancy. To use

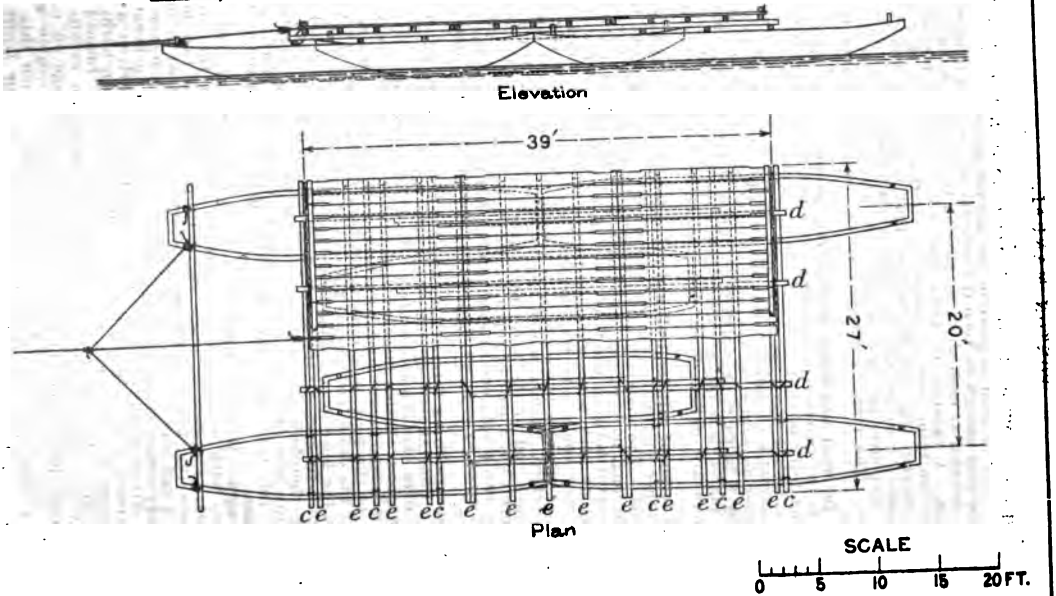


FIG. 16.—Raft for flying ferry from the equipage.

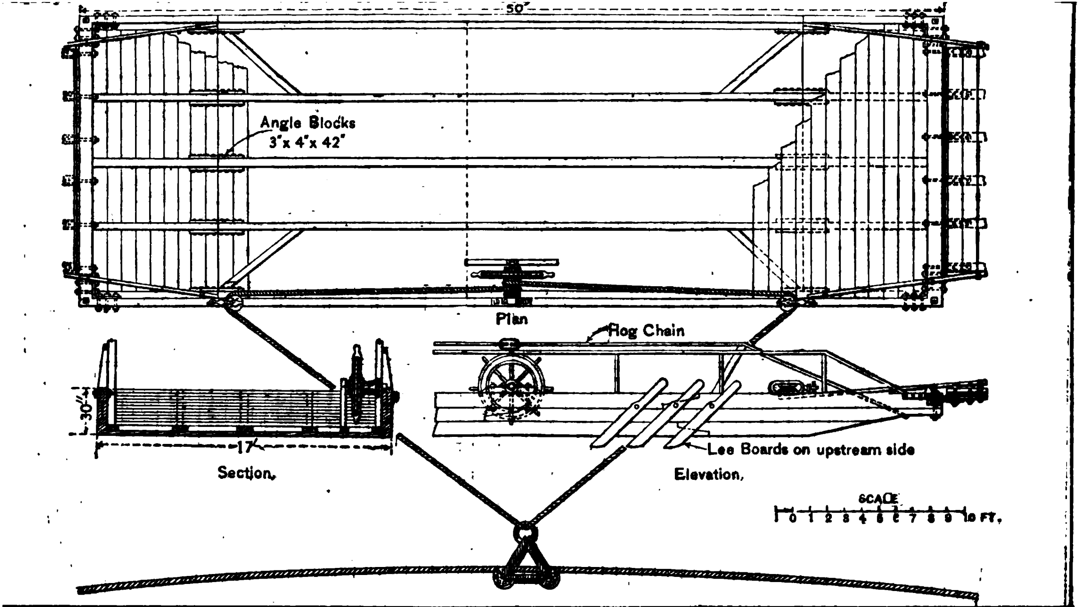
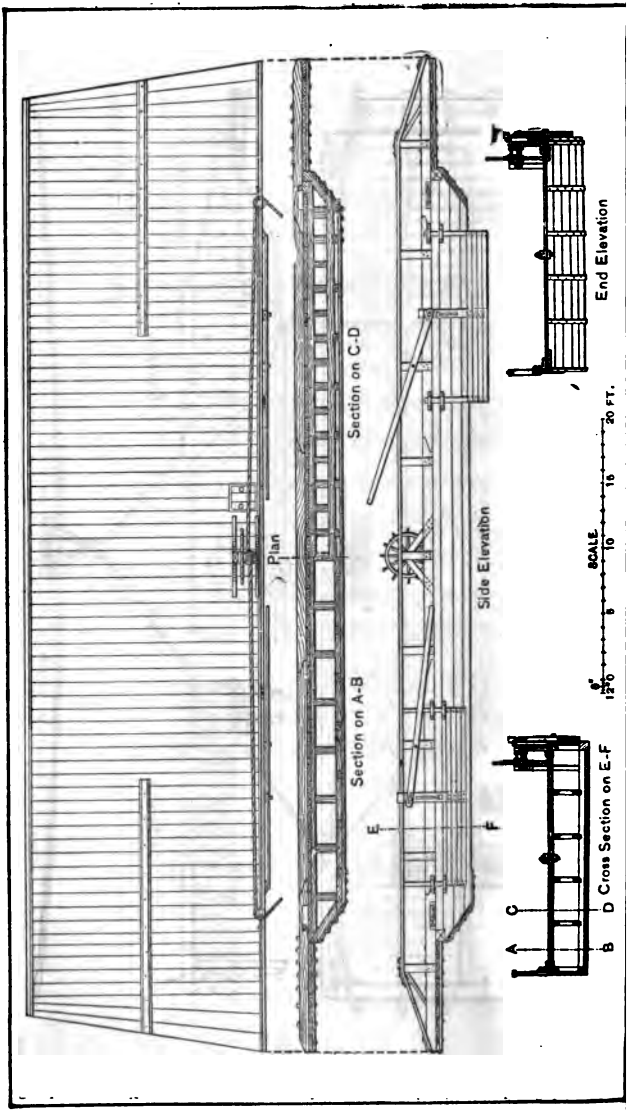


FIG. 17.—Permanent trail ferry.


Plan
Section on C-D
Section on A-B
Side Elevation
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End Elevation
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it in this manner a light frame of poles is built on the canvas and filled with the material for stuffing. The canvas, which has previously been well soaked, is brought up over the stuffing and its edges well lashed together. Care should be taken to cover the corners of the frame with hay. An ingenious barrel float suitable for one man in the absence of skiffs is shown in figure 22. An improvised boat can be made by covering a wagon body with paulins.

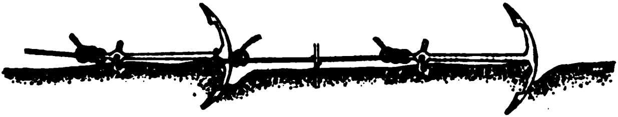


FIG. 19.—Two anchors.

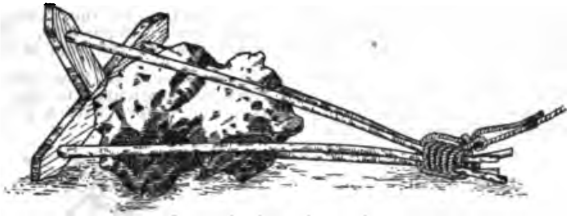


FIG. 20—Panniers of stone.

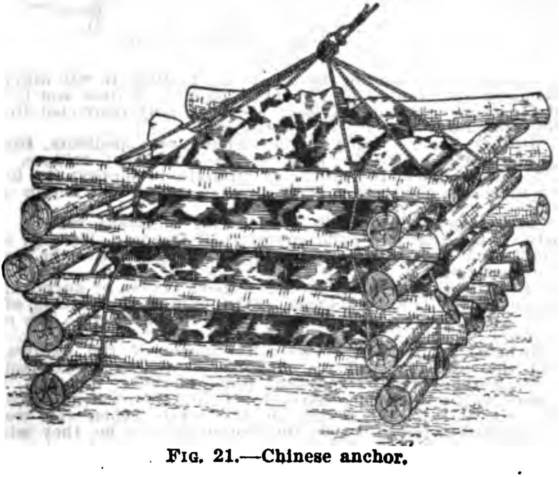


FIG. 21.—Chinese anchor.

PASSAGE BY MILITARY BRIDGES.

61. In the passage of nonfordable streams military bridges are always to be preferred when circumstances will permit their establishment. Such a bridge consists of a roadway and its supports. The roadway is formed of beams or balks reaching across the adjacent supports and covered with planks called chess. The supports may be fixed, as trestles, gabions, carriages, piles, or floating, as pontons, boats of commerce, rafts, etc.

Ponton bridges are preferable to all others when a passage by surprise or by main force is to be undertaken, and may be constructed on any stream of sufficient depth.

Pontons may be replaced by rafts when the velocity of the stream does not exceed 6 feet per second. In swifter currents rafts are unmanageable, drag their anchors, and are liable to destruction from floating bodies.

Trestle bridges may be constructed in rivers whose depth does not exceed 9 feet and whose velocity is not more than 6 feet per second. They may be employed with advantage in rivers of moderate depth and gentle current, with hard, even bottoms. When the bed of the river is uneven the adjustment of the trestles to the bottom is very tedious, and if the current is rapid almost impossible. When the bed is of mud of fine sand the settlement of the legs is liable to be irregular.

Gabion bridges may be used over marshes and shallow streams. They consist of gabions placed in rows perpendicular to the axis of the bridge, filled with stone or gravel, and capped with a piece of timber on which the balks rest.

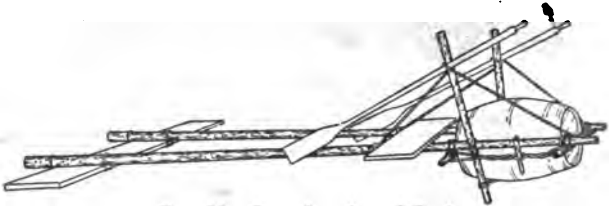


FIG. 22.—Ingenious barrel float.

Pile bridges are superior in point of stability to all other military bridges, but because of the large amount of time and labor required for their construction their use is usually restricted to securing the communications in rear of the army.

62. Military bridges being merely temporary expedients, the same solidity is not required in them as in permanent bridges. It is sufficient to give them the necessary strength to support the heaviest loads which accompany an army and to resist the action of the current.

The first requisite is attained by giving sufficient volume to the supports, if floating, and sufficient vertical strength, if fixed, and by using balks and chess of the proper size to correspond to the distances between bearings.

To resist the action of the stream a good system of anchorage, the reatest possible distance between supports, and the placing of these upports with the greatest dimension exactly parallel to the current re required.

An intimate connection between the parts of the roadway and etween the roadway and its supports is also a great assistance n resisting the current; sufficient play, however, must be left to llow the bridge to accommodate itself to the heaviest loads passing over it and to the action of the waves when the water is rough; otherwise, however firm the fastenings may be, they will soon work loose.

The interval between the supports is regulated not only by the strength of the balks, but also by the cross section and the buoyant power of the supports.

63. The duties of an officer charged with the construction of a bridge are to discover and collect all materials available for the purpose, to examine carefully the position chosen for the bridge, and to ascertain the width and velocity of the stream and the nature of its bottom and banks. He can then determine the composition of the bridge, taking care to reserve sufficient material to repair damages and to lengthen the structure in case of a rise in the stream. He will then divide his force into detachments, assign to each his duty, and require each to labor at its own task, without attempting to interrupt or assist that of any other detachment.

During the progress of the work he will not allow any unnecessary person to approach the working parties or to step upon the bridge.

CHAPTER 2.

BRIDGE EQUIPAGE.

1. The United States bridge equipage is composed of heavy and light trains. The former are intended to accompany large bodies of troops in the field, and are provided with the material necessary for the construction of bridges of sufficient capacity to pass large armies with their trains over rivers of any size and rapidity.

The light equipage is intended for use of rapidly moving columns, cavalry expeditions, etc., and is organized both as regards material and wagons with a view to rapidity of movement. At the same time it is capable of furnishing a bridge which will meet all the requirements of troops engaged on such service.

HEAVY EQUIPAGE.

2. **Organization.**[1]—The trains of the heavy equipage are composed of six ponton divisions and one supply division.

3. **Ponton divisions.**—Each ponton division is complete in itself, containing all the material necessary for constructing a bridge of 11 bays or 225 feet, and consists of 2 ponton sections, 2 abutment sections, and a ponton tool wagon. *Each ponton section* contains 3 ponton wagons and 1 chess wagon, and *each abutment section* contains 1 ponton, 1 chess, and 1 trestle wagon. The ponton section contains the material for 3 bays, and should never be subdivided. The division may be increased or diminished at pleasure by changing the number of its ponton sections.

4. **Ponton wagons.**—Each ponton wagon carries 1 ponton, 7 long balks, 1 anchor, 1 cable, 5 oars, 2 boat hooks, 20 lashings, 6 rack sticks, 1 pump, 1 ax, 1 hatchet, 1 bucket, 9 rowlocks (2 permanently stapled to ponton), 20 pounds of marline, 5 pounds of axle grease, 1 spare tongue, and 1 spare singletree.

5. **Trestle wagons.**—The trestle wagon is identical with the ponton wagon and carries 7 long balks, 7 trestle balks, 1 trestle complete, 1 cap lever, 8 pickets, 2 sills, 2 saddle transoms, 2 half coils of 3-inch circumference rope 720 feet each, 1 bucket, 1 ax, 1 spare tongue, and 1 spare singletree.

6. **Chess wagons.**—Each chess wagon carries 60 chess, 1 bucket, and 1 ax.

7. **Ponton tool wagon.**—The ponton tool wagon carries the following equipment and supplies:

BLACKSMITH EQUIPMENT.

	Comp't letter.
1 anvil, blacksmith, 100-pound	L
2 aprons, leather	H
2 bags, coal, canvas, 2-bushel	I
1 brace, ratchet, drill	A
1 chisel, cold	M
1 chisel, cold, handled	M
1 chisel, hot, handled	M
1 clinch cutter (buffer)	M
1 clinching iron	M
1 countersink, iron	M

---

[1] Tables of Organization, 1917, assign to the Engineer train of each Infantry division two ponton divisions and one-third supply division, except pile driver and spare ponton tool wagon. The two latter will be assigned to advance depots in proportion of 1 to each 3 Infantry divisions supplied. (*C. P. M. No. 1.*)

	Comp't letter.
Drills, twist, set of 13	M
3 files, flat, bastard, 16-inch	M
1 file, flat, smooth, 16-inch	M
1 file, half round, bastard, 16-inch	M
2 files, mill, bastard, 16-inch	M
1 file, mill, second-cut, 16-inch	M
1 file, round, bastard, 12-inch	M
1 file, round, bastard, 8-inch	M
1 flatter, handled, 3-inch	M
1 forge, portable, Empire, in box as furnished by Ordnance Department	I
2 fullers, handled, top and bottom, ⅜-inch	M
1 hammer, ball peen, handled, 3-pound	M
1 hammer, cross-peen, handled, 3-pound	M
1 hammer, farrier's handled	M
1 hammer, riveting, handled	M
1 hammer, set, handled	M
1 hammer, sledge, handled, blacksmith's, 10-pound	I
1 hammer, straight peen, 2-pound	M
1 hammer, turning, handled	M
1 handle, chisel, hot	M
1 handle, flatter	M
8 handles, file	M
1 handle, fuller, top	M
1 handle, hammer, farrier's	M
1 handle, hammer, machinist's	M
1 handle, hammer, sledge, 10-pound	I
1 hardy	M
3 headers, rivet	M
3 heading tools, ½-inch, ¾-inch, 1-inch	M
2 knives, shoeing	M
1 knife, toe	M
1 nipper, shoeing	M
1 oiler, ½-pint, brass	A
1 pincers, shoeing	M
1 pipe cutter, No. 2	M
1 pritchel	M
1 punch, fore and creaser	M
2 punches, round, handled, ⅜-inch and ¾-inch	M
2 punches, square, handled, ⅜-inch and ¾-inch	M
1 rake, fire	I
3 rasps, shoeing, 16-inch	M
1 rule, 2-foot, 4-fold	A
1 shovel, fire	I
1 stocks, taps and dies, pipe and bolt; Armstrong's No. 2, set	G
1 swedges, top and bottom, set ¼-inch to 1-inch by quarters	M
1 tire measurer	G
1 tong, shoeing	M
2 tongs, smith's, gad; ¾-inch and 1-inch	M
2 tongs, smith's, straight	M
1 vice, blacksmith's	I
1 wrench, monkey, 18-inch	M

BLACKSMITH SUPPLIES.

5 borax, pounds	B
4 coal, blacksmith's, bushels	I
25 nails, horseshoe, pounds	A
40 nuts, assorted, pounds	G
1 oil, machine, quart	F
5 steel, tool, feet	N
80 steel, in bars, assorted, feet	N

MISCELLANEOUS EQUIPMENT.

	Comp't letter.
3 bags, nail, 10-pound	I
1 bag, nail, 35-pound	I
2 bags, canvas, small, for nails and small stores	K
2 buckets, galvanized-iron	F
1 hammer, sledge, 8-pound	I
2 irons, calking, set; No. 1, 2, and 3 crease	M
12 lanterns, Dietz	C
2 mallets, calking	I
2 mauls, wood	I
1 palm, sail	A
1 rope, 3-inch circumference, half coil, 720 feet	J

MISCELLANEOUS SUPPLIES.

25 bolts, drift, ½-inch	D
25 bolts, drift, ¾-inch	D
1 canvas, 0000, 36 inches wide, rolls of 10 yards	E
50 grease, axle, pounds	F
20 cotton, calking, pounds	E
25 marline, pounds	I
10 nails, galvanized wire, 8-penny, pounds	I
35 nails, galvanized wire, 10-penny, pounds	I
10 nails, galvanized, boat, 10-penny, pounds	I
10 nails, galvanized, boat, 16-penny, pounds	I
6 needles, sail	A
10 oil, coal, gallons	F
2 screws, galvanized, 1¼-inch, No. 12, gross	G
4 screws, galvanized, 1¾-inch, No. 12, gross	G
10 screws, galvanized, 1¾-inch, No. 18, gross	G
1 screw, galvanized, 3-inch, No. 18, gross	G
5 screws, galvanized, 5-inch, No. 22, gross	G
1 screws, galvanized, 3½-inch, No. 18, gross	G
6 twine, sail, balls	A
24 wicks, lantern, Dietz	A

8 king bolts.
100 cotters, assorted sizes.
10 dowers for balk, complete with bolt and nuts.
15 open links.
22 linch pins.
22 linch-pin washers.

(*C. P. M. No. 1.*)

SADDLER'S EQUIPMENT—L.

12 awl blades, harness, assorted.
1 awl, pegging.
1 awl, seat, handled.
2 bags, canvas, for small stores.
2 blades, draw gauge, with followers (extra).
1 carriage, pricking, 3 wheels, numbers 7, 8, and 10.
1 chest, saddler's.
1 clamp, stitching. (Part of stitching horse.)
1 compass, 6-inch.
1 creaser, double.
1 gauge, draw, brass.
1 handle, peg awl, with wrench.
6 handles, awl, flat, assorted, 6 sizes.
1 hammer, riveting, No. 3.
1 horse, stitching.
1 knife, round.
1 knife, shoe, broad point.
1 knife, shoe, square point.
1 knife, splitting.
1 needlecase, leather.
1 needles, glover's, No. 3, paper.
2 needles, harness, No. 4, papers.
2 needles, harness, No. 5, papers.
2 needles, harness, No. 6, papers.
1 needles, sacking, Nos. 4 and 4½, assorted, paper.
1 nippers, cutting, 10-inch.
1 oilstone.
1 pliers, 6-inch.
1 punch, revolving, 4 tubes, Nos. 4, 5, 6, and 7.
4 punches, round, hand, Nos. 5, 7, 8, and 10.
1 palm, sewing, leather.
1 rivet set.
1 rule, boxwood, 2-foot, 4-fold.
1 screw driver, 3-inch blade.
1 shears, 10-inch.
1 slicker, steel.
1 tool, claw.
1 tool, edge, No. 1.
1 tool, edge, No. 2.
2 thimbles.

SADDLER'S SUPPLIES.

	Comp't letter.
1 beeswax, pound	B
1 brown wax, pound	B
3 buckles, roller, iron, ⅝-inch	A
6 buckles, roller, iron, ¾-inch	A
20 buckles, roller, iron, ⅞-inch	A
6 buckles, roller, iron, 1-inch	A
4 buckles, roller, iron, 1¼-inch	A
6 buckles, roller, iron, 1½-inch	A
2 cord, sash, ½-inch, pieces, 100 feet each	H
1 needle, collar, No. 4	A
1 needle, collar, No. 4½	A
1 oil, sperm, quart	B
12 oil, harness, quarts	B
4 oil, neat's-foot, gallons	B
1 rawhide, side, soft	K
1 rivets and burrs, brass, ⅝-inch, No. 10, pounds	G
1 rivets and burrs, brass, 1-inch, No. 8, pounds	G
30 soap, harness, pounds	B
12 soap, castile, pounds	B
70 sponges	K
1 tacks, copper, 12-ounce, paper	G
1 tacks, copper, 20-ounce, paper	G
1 tacks, iron, 12-ounce, paper	G
1 tacks, iron, 18-ounce, paper	G
1 tacks, iron, 8-ounce, paper	G
1 thread, shoe, brown, No. 3, pound	H
1 thread, shoe, brown, No. 10, pound	H
3 thread, shoe, half bleached, No. 10, pounds	H
1 thread, linen, carpet, No. 18, pound	H

SPARE PARTS.

1 doubletree.
1 stretcher.
1 lead bar.

8. **Supply division.**—This division is provided with articles necessary to replace material lost or worn out such as balks, chess, spare parts of wagons, and 1 pile driver. The wagons of this division are normally 5 ponton, 6 chess, 1 ponton tool, and 3 army wagons.

9. Three of the ponton wagons carry 17 long and 7 trestle balks each. The remaining two carry the pile driver. Each chess wagon carries 60 chess. The tool wagon carries the same load as that of a ponton division. The three army wagons carry the following supplies:

3 half coils, 3 inches circumference, 720 feet each, manila rope.
12 coils, 1 inch circumference, 720 feet each, manila rope.
1 coil, 4½ inches circumference, 720 feet each, manila rope.
30 rack collars.
3 kegs, 30-penny, spikes.
3 kegs, 60-penny, spikes.
200 driftbolts, ½-inch.
100 driftbolts, ¾-inch.
500 feet ½-inch wire hoisting rope.
500 feet ⅝-inch wire hoisting rope.
20 wire-rope clips, ½-inch and ⅝-inch.
1 10-inch wire-rope snatch block.
1 14-inch wire-rope snatch block.
Bars, soft steel, ⅝ by 1¾ inches, 9 feet long—2.
Bars, soft steel, ⅝ by 2 inches, 9 feet long—2.
Bars, soft steel, 1 by 2 inches, 9 feet long—2.
Bars, soft steel, ½ by 1 inch, 9 feet long—4.
Bars, soft steel, ½ by 2 inches, 9 feet long—2.
Bars, soft steel, ½ inch round, 9 feet long—6.
Bars, soft steel, ¾ inch round, 9 feet long—4.
Bars, soft steel, 1 inch round, 9 feet long—2.
100 pounds axle grease.
50 gallons kerosene in 5-gallon cans.

10. A full description of each of the principal items will be found in the specifications. For convenience a brief description of the various items is given here.

11. **Ponton.**—The ponton is 31 feet in length, with a maximum breadth of 5 feet 8 inches and a depth of 2 feet 8 inches at the center. Its displacement at the gunwale is about 21,280 pounds. In the bridge the maximum safe net buoyancy of the pontoon may be taken at about 18,000 pounds. For ferrying troops the capacity is limited by space rather than buoyancy.

12. **Trestle.**—The trestle consists of a cap with pins, two legs with shoes and keys and two wedges. The legs are inclined, to give lateral stability. The cap is adjusted by means of two cap levers, one of which is carried on each trestle wagon.

13. **Balks.**—The balks are 5 inches by 5 inches in cross section. There are two kinds of balks used with the heavy equipage. The *long balk* is 27 feet long, and is provided at each end with an oak cleat and a dowel hole. The clear distance between cleats is 25 feet 8 inches, giving a normal bay of 20 feet center to center of pontons. The bays between the pontons and the trestles are 22 feet 6½ inches from center of ponton to center of trestle cap. The *trestle balk* is 21 feet 8 inches long and is provided at each end with a dowel hole and two oak cleats forming a claw with an 8-inch opening. The distance from center to center of claws is 20 feet, giving a bay 20 feet long. The balks are also used for side rails.

14. **Chess.**—The chess is a plank, 13 feet by 12 inches by 1½ inches. The width at each end is reduced to 10½ inches for a distance of 2 feet, thus forming a notch on each side of the roadway for the passage of the side rail lashings. The middle line across each chess is marked on both sides with a fine saw cut.

15. **Saddle transom.**—The saddle transom is 5 feet 4 inches by 8 by 4 inches, with a strong steel hook at each end to fit over the gunwales of the ponton. There are two small cleats on the middle of the transom, forming a recess 6½ inches wide to receive a sill.

16. **Sill.**—The sill is 14 feet by 8 inches by 6 inches, scored to mark the position of the balks. For ease in handling it is provided with a ring in each end. The same sill is used either as an abutment or as a saddle.

17. **Miscellaneous items.**—The *anchor* is the kedge, weighing 150 pounds. The *boat hook* is of the ordinary form, 10 feet in length. The *bucket* is the ordinary galvanized-iron bucket. The *cable* is of 3-inch circumference manila rope, 240 feet in length. The *balk and side rail lashings* are of 1-inch circumference manila rope, 18 feet in length, whipped at one end with an eye-splice at the other. The *oar* is of the ordinary form 14 feet in length. The *picket* is of oak or hickory, 3 feet long and 3 inches in diameter, protected at both ends with steel. The *pump* is of galvanized sheet steel. The *rack collar* is of strap steel, made in two parts united by a link on each side. The inside measurement of the collar is 1 foot 7 inches by 5 inches. Folding oak wedges are used with rack collars. The *rack stick* is of hickory 2 feet long and 1½ inches in diameter.

18. **Wagons.**—The wagons are of three types—ponton wagons, chess wagons, and ponton tool wagons. The ponton wagon differs from the chess wagon only in being of heavier construction, in having longer side rails, and in the form of standards for securing the load. The ponton tool wagon is of different construction. All important details are shown in the book of plates.

19. **Wagons and their loads.**—The ponton wagon (figs. 23 and 24) is loaded by first placing 7 long balks between the side rails and entering the dowels on the front bolster into the holes in the balks. Above this course of balks is placed the ponton, stern foremost—the stern rings about 15 inches in advance of the front axle. The ponton is secured by lashing its rings firmly to those of the wagon. The anchor is slung under the side rails; the cable is coiled as far forward as possible in the ponton; the oars, boat hook, and pump are laid in the ponton, and the small articles stowed in the ponton locker. The ax and bucket are slung on the rear axle. The spare tongue is car-

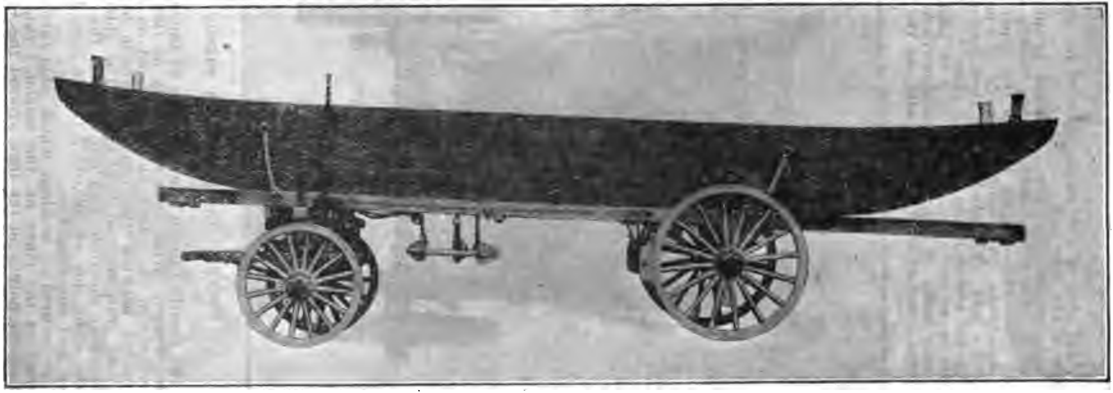


Fig. 23.—Loaded ponton wagon.

ried on the right side of the wagon secured in brackets attached t the inside face of the side rail.

20. The chess wagon (fig. 25) is loaded by placing a course o 30 chess on edge, with their lower notches resting on the center an rear bolsters. The transoms are laid on the upper notches, abuttin against the standards. A second course of 30 chess is then place directly over the first. The binders are then hooked on and secured The ax and bucket are slung on the rear axle.

21. The trestle wagon (figs. 26 and 27) is loaded as follows: course of 7 long balks is first placed as described in paragraph 1 The next course consists of 7 trestle balks on the right side of th

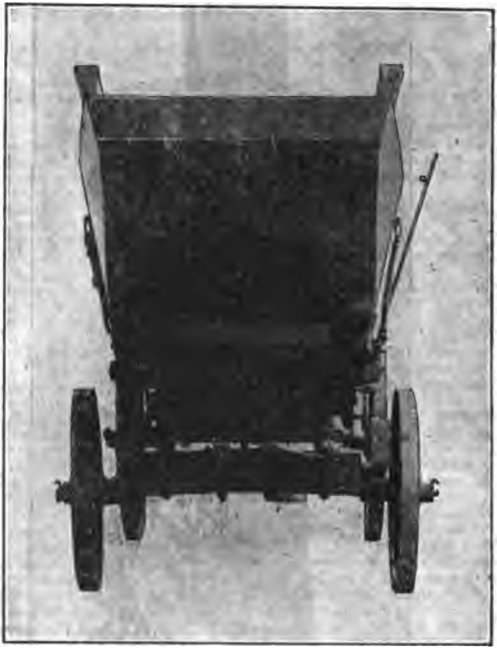


FIG. 24.—Loaded ponton wagon.

wagon and the trestle cap on the left side of the wagon, top to th left, with the wedges thrust into the cavity at the bottom. Adjoi ing the inner side of the cap a shoe is placed on edge at each en forming a pocket between the cap and trestle balk in which a stowed 1 saddle transom and 8 pickets. The third course consis of 2 sills placed at the right and left sides of the wagon; adjoinin the sill on the right side are placed 2 trestle legs, 1 saddle transo the cap lever, and one singletree.

The sills are secured by lashings which pass through the end rin and are lashed to the rings on the wagons; this same lashing secured around the points on the legs, around the hook on the saddl

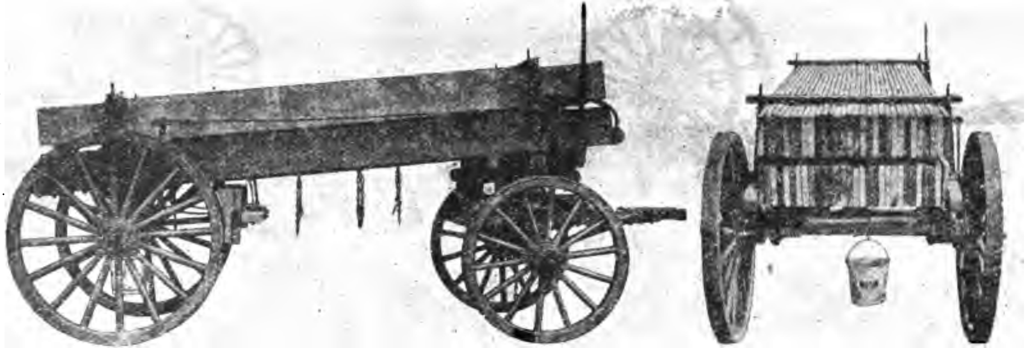


FIG. 25.—Loaded chess wagon.

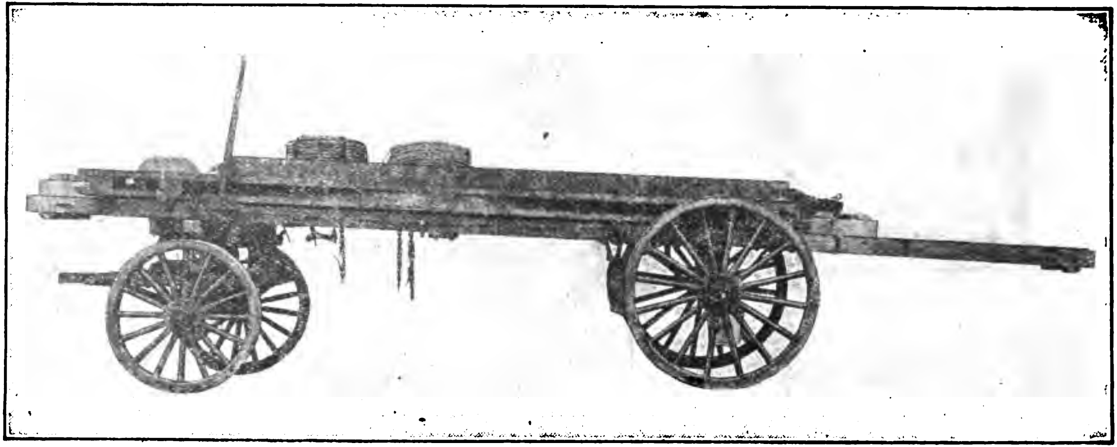


Fig. 26.—Loaded trestle wagon.

transom, through the jaw end of the cap lever, and through the opening in the shoe. The two half coils of 3-inch circumference rope are laid on top of the trestle balk and lashed to the forward rings of the wagon and also to the rear lashing chain. The ends of the trestle balks are secured by taking three turns of lashing around the first and second course between the cleats of the second course, and then making fast to the lashing ring attached to the chains at the rear end of the wagon. The spare tongue is carried as described for the ponton wagon. The ax and bucket are slung on the rear axle.

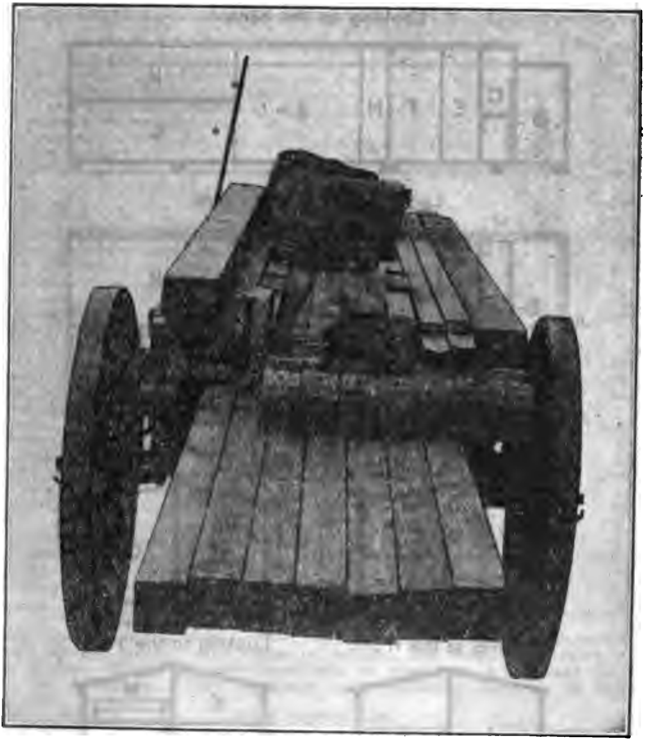
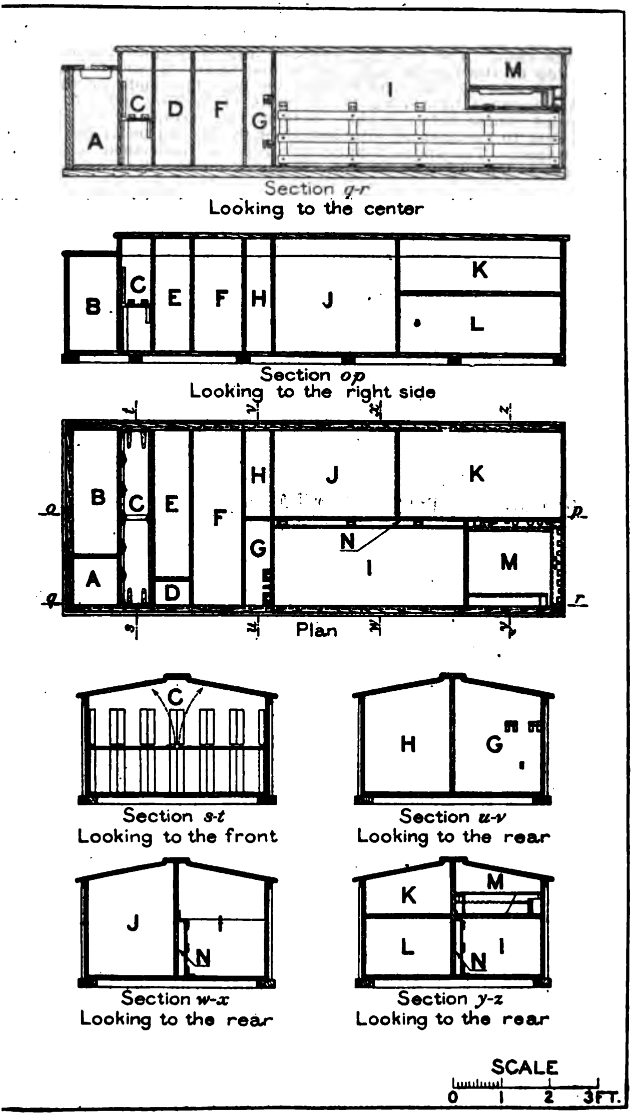


FIG. 27.—Loaded trestle wagon.

22. The interior of the ponton tool wagon (fig. 28) is divided into lettered compartments as shown in the drawings. The contents are loaded as follows:

Blacksmith equipment in compartments A, G, H, I, L, M.
Blacksmith supplies in compartments A, B, F, G, I, N.
Miscellaneous equipment and supplies in compartments A, C, D E, F, G, I, J, K, M.
Saddler's equipment in compartment L.
Saddler's supplies in compartments A, B, G, H, K.



Section q-r
Looking to the center

Section op
Looking to the right side

Plan

Section s-t
Looking to the front

Section u-v
Looking to the rear

Section w-x
Looking to the rear

Section y-z
Looking to the rear

FIG. 28.—Method of loading ponton tool-wagon body.

The compartment in which each article can be found is shown by the letter after the article in the list of equipment and supplies under paragraph 7.

23. **Weights.**—The weights of the loaded wagons vary considerably. The following are average weights of the equipage as now constructed:

Articles.	Number in a division.	Average unit weight.
		Pounds.
Ponton wagon fully loaded		5,500
Chess wagon fully loaded		5,160
Trestle wagon fully loaded		5,360
Ponton tool wagon fully loaded		4,510
Ponton and trestle wagons	10	2,580
Chess wagons	4	2,420
Ponton tool wagon	1	2,490
Anchors	8	150
Axes	14	5
Balks, long	70	150
Balks, trestle	14	120
Boat hooks	16	5
Buckets, galvanized iron	14	4
Cables (240 feet)	8	60
Cap levers	2	55
Chess	240	43
Doubletrees, spare	1	30
Hatchets	8	3
Lashings	160	.5
Lead bars, spare	1	47
Marline, coils	8	20
Oars	40	16
Pickets	16	9
Pontons	8	1,600
Pumps	8	8
Rack sticks	48	1
Rope, 3 inches circumference, half coils, 720 feet each	4	180
Row locks	72	1
Saddle transoms	4	46
Sills	4	130
Singletrees, spare	10	6
Stretchers, spare	1	25
Tongues, spare	10	76
Trestles, complete	2	530

24. **Animals and harness.**—Each ponton or trestle wagon is normally drawn by six mules; each chess or ponton tool wagon is drawn by four mules. Under adverse conditions of roads, an additional team may be necessary. The ordinary quartermaster harness is used (fig. 29).

LIGHT EQUIPAGE.

25. **Organization.***—The trains of the light equipage are composed of 3 ponton divisions, each of which consist of 8 ponton, 2 chess, and 2 trestle wagons. All wagons are identical with the chess wagon of the heavy equipage. Each division of light equipage is accompanied by a ponton tool wagon identical with that of the heavy equipage. The ponton wagon carries all the material necessary for constructing a complete bay. The division may, therefore, be increased or diminished by one or more ponton wagons without disorganizing it. The normal division contains all the necessary material for constructing 185 feet of bridge.

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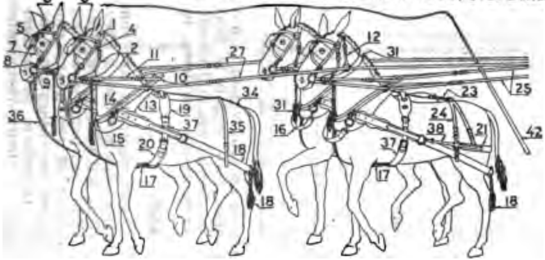
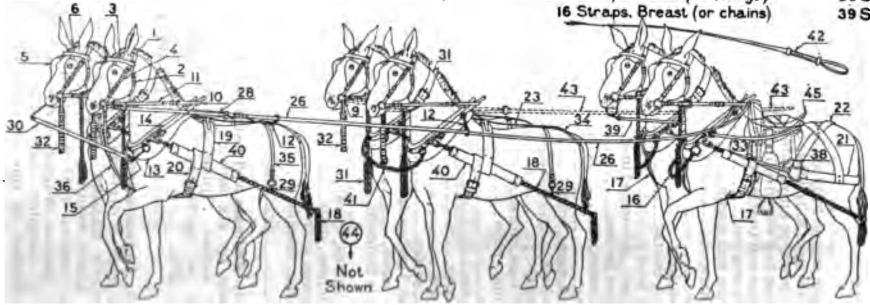
* Tables of Organization, 1917, contemplate that one complete train of light equipment shall constitute the ponton section of the Engineer train of each Cavalry division. (*C. P. M. No. 1.*)

STANDARD TYPES OF HARNESS, U. S. BRIDGE EQUIPAGE



FOUR-LINE AMBULANCE HARNESS.



SIX-MULE JERK LINE HARNESS

NOMENCLATURE

1 Crown Piece
2 Straps, Throat
3 Bands, Brow
4 Check Pieces
5 Blinds
6 Winker Stays
7 Face Pieces
8 Straps, Bit
9 Bits, Bridle, Amb. #47-A
10 Reins, Bridle, Long
11 Reins, Bridle Short
12 Straps, Rain
13 Collar
14 Hames
15 Straps, Hame (or strings)
16 Straps, Breast (or chains)
17 Straps, Choke
18 Traces, (trace chains)
19 Bands, Back (straps, back)
20 Bands, Belly
21 Breeching
22 Straps, Breeching
23 Straps, Turnback
24 Straps, Hip
25 Lines, 2 Horse, Check
26 Line, Jerk
27 Lines, 4 Horse, Check
28 Over Jerk
29 Strings, Trace
30 Stick, Jockey
31 Straps and Chains, Neck
32 Straps, Tie
33 Straps, Spider
34 Crupper, Lead
35 Straps Carrying
36 Martingales
37 Tugs, Back Strap
38 Straps, Side
39 Strap, Coupling
40 Pipe, Chain or Trace
41 Chain, Bearing
42 Whip Black snake or stock and lash

Not Supplied

43 Line, Surge, Made from over-jerk
44 Fifth Chain, Connects leader's spreader to tongue
45 Saddle

26. **Ponton wagons.**—Each ponton wagon carries 7 short balks, 16 short chess, 2 side frames, 1 cable, 1 anchor, 1 ax, 1 bucket, 1 spare tongue, 1 spare singletree, and a ponton chest containing 1 ponton cover, 14 transoms, 5 paddles, 2 scoops, 20 lashings, 2 boat hooks, 1 pump, and 8 rack sticks.

27. **Chess wagons.**—The chess wagon carries 50 short chess, 1 ax, 1 bucket, and a box containing 2 spare ponton covers.

28. **Trestle wagons.**—The trestle wagon carries 7 short balks, 7 trestle balks, 1 trestle (complete), 1 sill, 1 half coil of 3 inch circumference rope (length 720 feet), 1 half coil of 1 inch circumference rope (length 720 feet), 1 cap lever, 8 pickets, 1 ax, and 1 bucket.

29. **Ponton tool wagon.**—The load of the ponton tool wagon is the same as that of the heavy equipage, except that 2 sets of calking irons, 2 calking mallets, 20 pounds of calking cotton, and 1 stretcher are omitted, and 4 sail palms, 4 rolls of canvas, 1 dozen sail needles, and 6 balls of sail twine are added.

30. **Material.**—A full description of each of the principal items will be found in the specifications. For convenience a brief description of the various items is given here.

31. **Ponton frame** (fig. 30).—The ponton frame is formed of 2 side frames and 14 transoms, 2 of which are provided with mooring beckets. The transoms are provided with light metal tenons which fit loosely into corresponding metal mortises set in the side frames. The dimensions of all transoms, mortises, tenons, and side frames are identical, permitting the parts to be used interchangeably. All edges of the frames and transoms are well rounded to prevent chafing the canvas. The frame, when assembled, is held together by a rope passed through rings in the ends of the side frames and tightened with a rack stick.

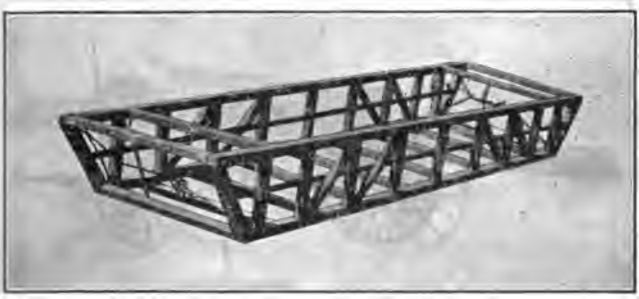


FIG. 30.—Ponton frame.

A special form of ponton frame which was used during the latter part of the Civil War by the Army of the Cumberland was made differently from the one which has just been described. The side frames were divided at the middle, the two parts being connected by stout hinges placed on the inside. The upper hinge was attached by screws; the lower was riveted. A greater number of transoms was used for the bottom of the boat and a couple of ropes were run through them, the slack of which was used to tie them into bundles when the boats were dismantled. There were also some differences in the framing of the sides and in the kind of transom used to connect all the parts together. The hinged canvas ponton frame has been modified by the experience gained from the use of the boats first built. The object in adopting this form was to dispense with the necessity of special ponton wagons. All the parts of the bridge except the balks could be carried without difficulty in the ordinary army wagon. Special wagons were required for the balks, but they were very quickly made by throwing off the body of an army wagon and lengthening the coupling. Under circumstances where it is essential to economize transportation by keeping all teams fully employed at all times or where a bridge equipage is suddenly prepared and there is no time to procure the regular ponton wagons the system just described may be used with advantage. The only ponton train carried by the Army of the Cumberland from Chattanooga to Atlanta, and thence to Savannah and Washington, was composed of hinged canvas pontons, and it gave general satisfaction.

32. **Ponton cover.**—The ponton cover is of 0000 kahki cotton duck, in three pieces, double seamed, with a double border 2 inches wide. The clew-line eyelets are of yellow metal. After the cover is assembled it is given a special waterproofing treatment.

33. **Balks.**—The short balks are 22 feet by 4½ inches by 4½ inches, with 20 feet 10 inches between the cleats, which are similar in construction to those of the heavy equipage. The trestle balk is the same as for the heavy equipage. Balks are used as side rails.

34. **Short chess.**—The short chess are 11 feet by 12 inches by 1½ inches, with notches at each end 18 inches in length; in other respects they are similar to those of the heavy equipage.

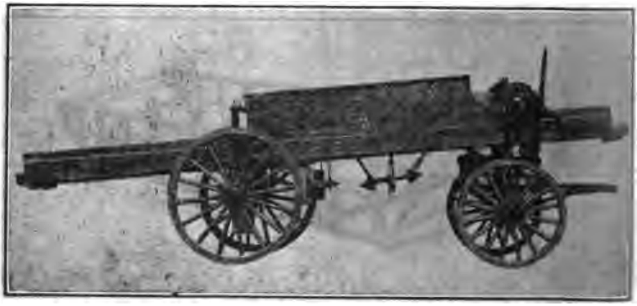


FIG. 31.—Loading the ponton wagon.

35. **Miscellaneous items.**—The *anchor* is a kedge weighing 75 pounds.

The *boat hook* is 8 feet long and of the usual construction, except that the points are blunted to prevent injuring the canvas.

The *cable* is of 3 inch circumference manila rope, 180 feet long.

The spare *cover box* is 7 feet 10 inches long by 14½ inches wide by 14 inches deep and contains two spare covers.

The *paddle* is of the ordinary form, 6 feet long.

The *ponton chest* is 8 feet by 2½ inches by 2 feet 4 inches by 1 foot inches; the lid is covered with canvas which overlaps 3 inches all round. It has strong rope handles at each end.

The *scoop* is the ordinary grocer's tin scoop.

The *trestles, sills, pumps, lashings, rack sticks, pickets,* and *buckets* are the same as for the heavy equipage.

36. **Animals and harness.**—Each of the wagons is normally drawn by four mules. Under adverse conditions of roads an additional team may be necessary. The harness is the same as with the heavy equipage.

37. **Loading the ponton wagon** (figs. 31 and 32).—To load the wagon seven short balks are laid on the right side between the rails, where they are secured by the front bolster dowels; on their left eight chess are placed on edge, with their notches resting on false bolsters which are attached to the center and rear bolsters. The two side frames are laid over the balks, with their bottoms against the chess. The wagon transoms are laid in the upper notches of the

ess, abutting against the standards. Eight more chess are laid rectly over the first course. The loaded ponton chest is placed top of the side frames and against the chess. The binders are oked down; the side frames are lashed by their rings and the est by its handles to the rings of the wagon. The cable is coiled d lashed on the side frames in front of the chest. The anchor is ung under the side rails and the ax and bucket on the rear axle. e spare tongue is carried on the left side, lashed to the standards. e singletree is carried in the ponton chest.

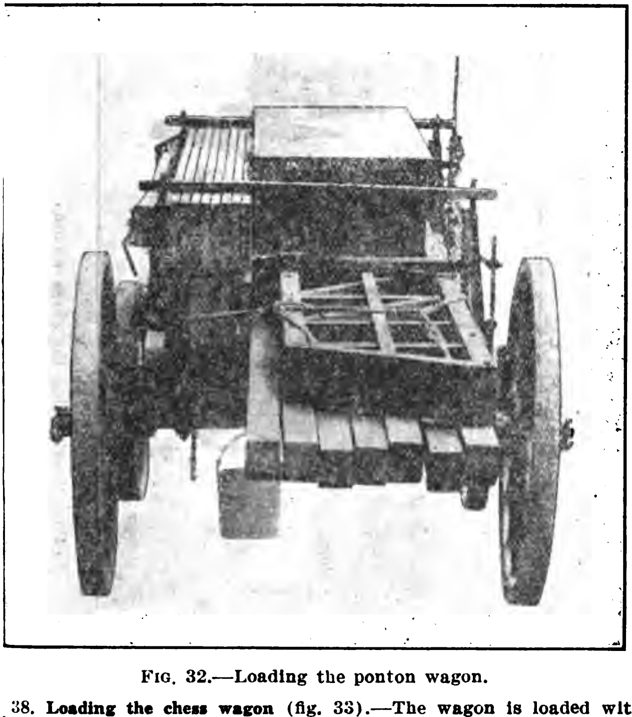


FIG. 32.—Loading the ponton wagon.

38. **Loading the chess wagon** (fig. 33).—The wagon is loaded with hess by first placing a course of 30 chess, as in the heavy equipage, nd on these a second course of 20 chess, 10 against the right and 0 against the left wagon standards. The upper course of chess is eld in place by the binders and the spare cover box, which rests n the lower course of chess. The ax and bucket are slung on the ear axle.

39. **Loading the trestle wagon** (figs. 34 and 35).—The first course onsists of seven short balks, placed side by side, beginning at the ight side of the wagon, one trestle balk, and one trestle leg. They ll rest on the front and rear bolsters, and the balks are secured by owels attached to the front bolster. The second course consists of ix trestle balks placed on top of the short balks at the right side

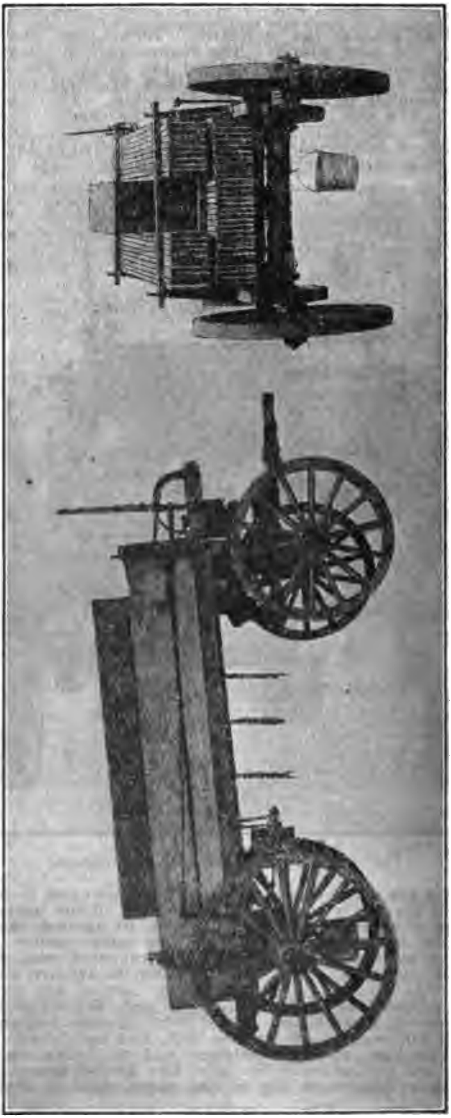


FIG. 33.—Loading the chess wagon.

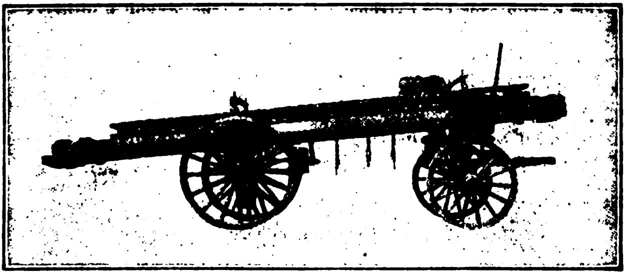


FIG. 34.—Loading the trestle wagon.

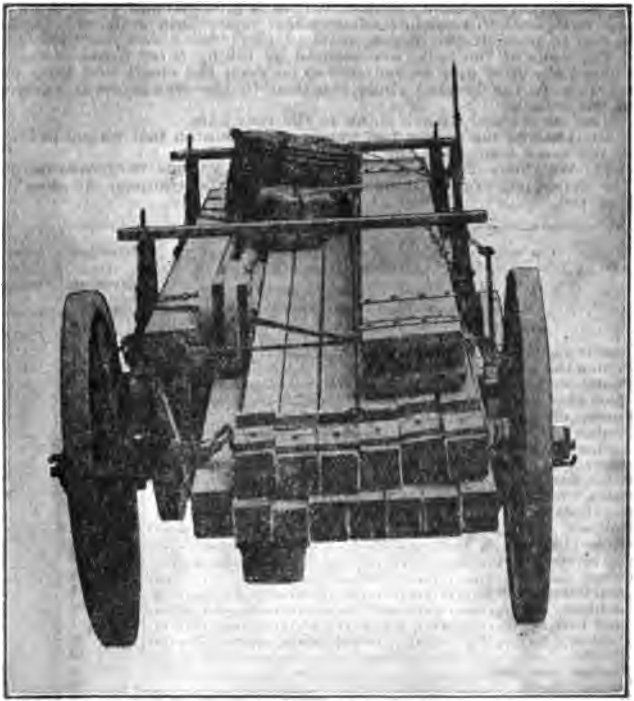


FIG. 35.—Loading the trestle wagon.

of the wagon; on the extreme left side of the wagon another trestle leg is placed on top of the trestle leg in the first course, then a sill is placed on top of the leg in the second course; this leaves a space between the sill on the extreme left of the wagon and the first trestle balk to the right of the wagon. The front end of this space is closed by the cap lever, which is secured by a lashing run through the lashing ring at the front standards and the end ring of the sill, then around the jaw end of the cap lever, and secured to the lashing ring of the front standard on the right side of the wagon. The rear end of this space is closed by placing the two shoes on their edges and securing them by a lashing run from the lashing ring on the left rear standard; thence through ring on the end of the sill; thence around the points of the trestle legs, back through ring of the left rear standard; thence over the top of sill and through the opening in the two shoes; thence through the leg opening of the trestle cap which is placed on the extreme right side of the wagon and on top of the trestle balks, and through the ring on the right rear standard, back through the leg opening of trestle cap; thence through ring on the end of the sill and secured to the ring on the left rear standard. The pocket thus formed contains eight pickets, two trestle wedges, and one handle for cap lever. On top of the second course in the center of the wagon is placed one half coil of 3 inch circumference rope and one half coil of 1 inch circumference rope; both coils are securely lashed to prevent shifting.

The ends of the balks are secured by taking three turns of lashing around the first and second course between the cleats and then making fast to the lashing rings attached to the standards at each end of the wagon.

The bucket and ax are slung to the rear axle.

40. **Loading the ponton tool wagon.**—The ponton tool wagon is loaded in the same manner as for the heavy equipage.

41. **Weights.**—The weights of the loaded wagons vary considerably. The following are the average weights of the equipage as now constructed.

Articles.	Number in division.	Average unit weight.
		Pounds.
Trestle wagon, fully loaded		4,750
Ponton tool wagon, fully loaded		4,510
Ponton wagon, fully loaded		4,580
Chess wagon, fully loaded		4,510
Ponton, chess, and trestle wagons	12	2,420
Ponton tool wagon	1	2,490
Anchors	8	75
Axes	12	5
Balks, short	70	90
Balks, trestle	14	122
Boat hooks	16	4
Buckets	12	2
Cables (180 feet)	8	45
Cap levers	2	55
Chess	228	35
Doubletrees, spare	1	30
Lashings	160	.5
Lead bars, spare	1	50
Paddles	40	6
Pickets	16	9
Pontons, complete	8	580
Ponton chests	8	170
Ponton covers, spare	4	110
Pumps	8	8

Articles.	Number in division.	Average unit weight.
		Pounds.
Rack sticks	64	1
Rope, 1 inch circumference, half coils, 720 feet each	2	25
Rope, 3 inches circumference, half coils, 720 feet each	2	180
Scoops	16	1
Sills	2	130
Singletrees, spare	8	6
Spare cover box	2	80
Tongues, spare	8	75
Trestles, complete	2	530

42. **Loads for forced marches.**—When a forced march is to be made, and it is desirable to lighten the loads, the chess may be removed from the ponton wagons, the rope from the trestle wagons, and the load of the chess wagons be reduced to 40 chess. The number of chess wagons in this case must be increased to five.

CHAPTER 3.

BOAT DRILL.

1. The pontons of the heavy train may be used in the passage of troops over rivers and for embarking and disembarking an army and its stores; moreover, the construction of bridges by night over deep and rapid streams is a common occurrence in a campaign. A well-instructed pontonier must, therefore, be a good boatman. The following exercises, designed to impart this knowledge, are to be thoroughly taught and frequently practiced, keeping in mind, especially in the school of the flotilla, that the chief aim is to render the troops expert in handling the boats, and to accustom them to maneuver without interference in restricted positions.

SCHOOL OF THE PONTONIER.

2. The object of this school is individual instruction in the use of the oars, paddles, and boat hooks. The drill should be carefully supervised by the commissioned officers of the company, who will move about from ponton to ponton, and see that every part of the drill is properly taught.

3. The instructor (usually a noncommissioned officer) embarks his detachment, consisting of six privates, and pushes out into deep water, where, if the current be strong, he casts anchor. The boat is provided with seven oars, two boat hooks, and one anchor and cable. The instructor, placing himself in the stern, details each private in turn to practice with the oar, the rest being allowed to lean against the gunwales, paying close attention to the drill.

4. At the command ATTENTION, the pontonier inserts the rowlock in the socket, and then facing aft places himself in the middle of the ponton abreast of his rowlock, assuming the position of a soldier as prescribed in infantry drill regulations.

5. At the command UP OARS, he grasps his oar and raises it briskly to the vertical in front of the center of his body, the handle resting on the bottom of the boat and the blade athwartships. The hand next to his rowlock grasps the oar at the height of the chest, elbow and wrist horizontal; the other steadies it at a point 12 inches lower.

6. At the command LET FALL, he moves one foot 18 inches perpendicularly toward the side opposite to his rowlock, and lowers his oar so that it touches the water before striking the gunwale; special attention is required that it does not fall upon the rowlock, into which it should be placed gently with the blade horizontal. He next slips one hand to the grip and places the other on the oar 8 inches from it. the backs of both hands being up and the wrists lowered, and moves the foot next to the rowlock 18 inches to the rear.

7. At the command GIVE WAY, given when the oar is at the final position indicated for LET FALL (or at HOLD WATER, in which case the oar is at once brought to this position), he raises his wrists and extends his arms, throwing the weight of the body well forward. drops the blade vertically into the water, throws his weight strongly backward upon the oar, disengages it from the water, and resumes his first position. These motions are repeated with regularity, taking care to make a long sweep, to keep the oar near the water, and to feather it by depressing the wrists after every emersion until the command WAY ENOUGH or OARS is given. The instructor will take

care that the oar be moved by the weight of the body and not by the force of the arms.

8. At the command WAY ENOUGH, given when the oar is in the water, the pontonier takes one stroke, raises his oar to a vertical position, and lays it gently in the ponton, the blade toward the bow.

9. At the command OARS, given when the oar is in the water, he takes one stroke if rowing, and resumes the final position indicated for LET FALL. If at the position HOLD WATER, the stroke is omitted.

10. At the command HOLD WATER, given when the oar is in the final position indicated for LET FALL, the pontonier raises the grip so as to engage the blade in the water, and holds the oar firmly at right angles to the boat, blade vertical. The object, of course, is to check the headway when in motion.

11. At the command STERN ALL, given when the oar is at HOLD WATER, or at the final position indicated for LET FALL, he reverses the operation of rowing as described under GIVE WAY, and by pushing vigorously against the oar when immersed, gives the boat a motion astern. The operation ceases at the commands WAY ENOUGH or OARS, which are executed as described above.

12. The command SCULL is given when the oar is in the final position indicated for LET FALL. Sculling is first taught by placing the pontonier at the rowlock in the stern which he faces. The oar is nearly balanced in a horizontal position in the rowlock, the blade horizontal, and is held by clasping the grip with both hands, the backs up and the right hand next the body. The feet are placed 30 inches apart on a line parallel to the stern, and at a convenient distance from it. At the command SCULL, the weight is thrown on the right leg, and the blade after being carried to the left, is immersed, giving it at the same time an inclination toward the right by depressing the right elbow. The weight is now thrown strongly on the oar, the body bending toward the left. The blade is turned at the same time in the water by varying the position of the elbows, so that at the end of the stroke it inclines toward the left ready for the reverse stroke—which is immediately given without letting the oar emerge from the water. This oblique passage of the oar through the water, to the right and left alternately, forces the boat forward; and by varying the amount of pressure in the alternate strokes the boat may be turned toward either side. To scull a boat skillfully requires considerable practice, which must first be acquired at the stern rowlock. Afterward the pontonier is required to execute the same movements at the side rowlock, placing himself in the most convenient position permitted by the length of the oar in use. At the command WAY ENOUGH or OARS the motion is terminated.

13. The command TRAIL is given when the oar is in the final position indicated for LET FALL, and only when it is attached by a trail line to the gunwale. The command is obeyed by unshipping the oar from the rowlock and letting it trail in the water alongside. At the command SHIP the oar is restored to its former position.

14. The command UNSHIP is given when the oar is in the final position indicated for LET FALL, and is executed by removing the oar from the rowlock and letting it trail alongside, held by the hand next the gunwale. This position is used whenever it is necessary to prevent fouling the oars suddenly, as in shooting a bridge. At the command SHIP the oar is restored to its former position.

15. The command BOAT OARS may be given when the oar is in the final position indicated for LET FALL or at UP OARS. The pontonier raises his oar to the vertical, if not already there, lays it quietly on the bottom of the boat, blade toward the bow, and takes the position of ATTENTION.

16. The command REST may be given when the pontonier is at ATTENTION or at TRAIL. He is no longer required to preserve silence or his position.

17. The use of the boat hook is too varied to be reduced to a manual. It is used for pushing the boat in shallow water, for holding it fast alongside another boat, or to the bank, for recovering articles lost overboard, and for other similar purposes.

18. Pontoniers should also be trained in the use of the paddle belonging to the light equipage. This training may be given in the wooden pontons, and a manual for it is not deemed necessary.

SCHOOL OF THE BOAT.

19. The object of this school is the instruction of the pontoniers in the management of the single boat. It is not to be taught until all of the crew are thoroughly familiar with the use of the oar, paddle, and boat hook, as described in the preceding school. The exercise will be conducted under the close supervision of commissioned officers, who will move from boat to boat and see that all the commands are thoroughly understood and properly executed. The right and left of a boat are the right and left sides when facing the bow.

20. **To embark.**—The instructor, a noncommissioned officer, provides his detachment with seven oars and two boat hooks, which are carried on the shoulders, blades or hooks well up, forms it in single rank, with the best oarsmen on the right, files it left in front into the ponton (supposed to be in the water, moored to the bank by the stern), and deposits the oars in the bottom of the boat, six with the blades toward the bow and the seventh reversed. The boat hooks are placed outside the oars, prongs toward the bow. The cable is coiled in the bow, with the lower end made fast to the right mooring post and the other attached to the anchor by an anchor knot. The anchor is placed with its arms projecting vertically over the bow and its stock resting on the gunwales aft of the mooring posts.

21. At the command ATTENTION (executed as in the School of the Pontonier) the crew arrange themselves in the order in which they were formed on shore, the right pontonier (stroke oar) taking the after right rowlock and the others alternating, the even numbers being on the left side. The instructor then directs one or two of the men next the stern to step on shore, remove the moorings, and prepare to push the ponton from the bank.

22. At the command UP OARS (executed as in the School of the Pontonier) the instructor takes the reversed oar himself and, drawing it aft horizontally, puts the blade over the side or stern and prepares to use it in pushing off from the bank.

23. At the command SHOVE OFF the men on shore, aided by the instructor and, if necessary, by others of the crew with their oars, disengage the ponton from the bank and jump in. All the oarsmen then assume the position of UP OARS, and the instructor places his oar in the stern rowlock in readiness to direct the course of the boat.

The command LET FALL (executed as in the School of the Pontonier) is then given.

24. **Simple exercises.**—The crew is next drilled to execute in unison the following movements as prescribed in the School of the Pontonier, the after right oarsman giving the cadence: GIVE WAY; WAY ENOUGH; UP OARS; LET FALL; OARS; HOLD WATER; STERN ALL; TRAIL; UNSHIP; SHIP; BOAT OARS; REST. In order to secure the simultaneous and prompt execution of these movements the preparatory commands similar to the following may be used: STAND BY TO GIVE WAY; STAND BY TO LAY ON OARS; STAND BY TO STERN ALL. These exercises will be continued until the entire crew can execute them properly. It is better to require vigorous exertion, interspersed with frequent rests, than to induce a habit of sluggish and irregular execution by overfatiguing the men. It should be added that the instructor need not shift his position when the men are backing, as he can readily steer from the stern. Indeed, the boat is moved in this direction with nearly the same facility as to the front.

25. When the crew is well drilled in the foregoing simple exercises the following more complicated movements will be taught:

26. **To turn the boat rapidly.**—The oars being at the final position indicated for LET FALL, the instructor commands, GIVE WAY RIGHT (or LEFT); BACK LEFT (or RIGHT). Pulling and backing oars keep stroke with the after oar of their own side. To cease

turning the instructor commands GIVE WAY, at which the backing oars take the direct stroke. Assisting with his own oar, the instructor can turn the ponton with great rapidity and in a very small space by this method.

27. **To move sideways.**—It is sometimes desirable to move the ponton a short distance to the right or left without advancing or backing. This is effected in the following manner: To move to right, the instructor directs the bow oarsman to shift his oar into the bow rowlock, moving the anchor a little if necessary, and to face to the right. The oars being at the final position indicated for LET FALL, he then commands LEFT PREPARE TO SCULL, faces to the right and prepares to back with his own oar. All being in position he commands BACK AND SCULL. The left oarsmen (without attempting to keep stroke) then scull, each through his own rowlock, and the instructor and the bow oarsman back steadily so as to preserve the boat parallel to its former position. The desired movement having been effected, the instructor commands OARS, when all take their previous positions. The movement to left is executed in a similar manner by the commands: 1. RIGHT PREPARE TO SCULL; 2. BACK AND SCULL.

28. **To cast anchor.**—The ponton is first headed to the current and its way checked. At the command PREPARE TO CAST ANCHOR, the right and left bow oarsmen boat their oars; the former unships the bow rowlock (if in the socket) and sees that the cable is clear, while the latter grasps the stock with both hands, each one foot from the shank, and stands ready to cast it overboard. At the command CAST ANCHOR, he tips it into the water and assists the right bow oarsman in paying out the cable. When the ponton has dropped astern (or been backed) about five times the depth of the water, they take a single turn around the left mooring post and hold strongly upon the cable to make the flukes take hold of the bottom. When this is accomplished they gradually pay out about as much more rope, and then secure the cable to the left mooring post by a mooring knot. In deep water a relatively less length of cable will suffice. The instructor then commands BOAT OARS.

29. **To weigh anchor.**—The crew being at ATTENTION, the instructor commands: 1. PREPARE TO WEIGH ANCHOR; 2. UP OARS; 3. LET FALL. At the first command the left bow oarsman loosens the cable from the mooring post, and aided by the right bow oarsman, passes it over the middle of the bow; they then stand ready to haul in. The remaining pontoniers obey the second and third commands as given. The instructor then commands GIVE WAY, and causes the ponton to be moved slowly toward the anchor, the bow oarsmen taking in the slack of the cable and neatly coiling it away in the bow. When the cable becomes vertical the way of the boat is checked, and the two men, pulling vigorously, raise the anchor to the bow, where it is held by the right bow oarsman, while the left bow oarsman grasps the stock with both hands, and, aided by the other bow oarsman, lifts it to its position already described. They then resume their oars and take the stroke.

30. **To debark.**—On approaching the landing place, the ponton being headed in the proper direction, the instructor commands IN BOWS. At this command the bow oarsman takes one stroke, and, boating his oar as directed in the School of the Pontonier, takes a boat hook and stands ready to assist in the landing. When sufficient way has been gained the instructor commands WAY ENOUGH, and the stroke oarsman takes the remaining boat hook to assist in the landing. The instructor with the steering oar then brings the ponton to the bank in the most convenient manner, causes the rowlocks to be unshipped and the ponton to be properly secured, and lands his men in a way similar to that prescribed for embarking them.

31. **To salute.**—When passing a boat containing a commissioned officer of superior rank to any in the ponton, the chief brings his crew to the position of OARS. The salute is acknowledged in the same way. The salute will not be given during drill, except whe directed by the officer in charge of the drill.

SCHOOL OF THE FLOTILLA.

32. A flotilla generally consists of one ponton division of eight boats, but it may comprise any number of boats greater than one. It is commanded by a commissioned officer, usually a captain, who, if practicable, should make use of a light boat, in order to enable him to move rapidly to any point where his presence may be required. Lieutenants in the pontons promptly rectify errors and prevent confusion.

33. All commands of the captain will be repeated by the lieutenants and, if necessary, by the chiefs of pontons. Preparatory commands will be separated from those of execution by a sufficient interval to allow the chiefs of pontons to add the requisite directions to their pontoniers. Commands of execution will be obeyed as soon as heard. Signals and whistles may be used, as in infantry drill regulations. Megaphones may be used if desired.

34. Inversions are ignored. The front is always toward the bows of the pontons; hence FORWARD always calls for a direct stroke and BACKWARD for a back stroke. In executing movements RIGHT and LEFT refer to the actual direction of motion.

35. The drill unit is the single boat. Two boats constitute a section. In line the pontons and sections are numbered from the actual right; in column of single boats the boats are numbered from the front; and in column of sections from the right and front. Thus in column of sections No. 1 is on right of the leading rank, No. 2 is on the left of No. 1, No. 3 is behind No. 1, No. 4 is behind No. 2, etc. Sections, when formed, are numbered in a similar manner. They are commanded by the senior lieutenant or sergeant in them, who gives the orders prescribed for the chiefs of pontons in the formation by boat, with any necessary additional directions.

36. The normal interval between boats in line is 20 yards and distance between boats in column 12 yards. These may be changed by the captain, but they must not be reduced below 12 yards and 4 yards, respectively. In a very rapid current they should be considerably increased. In the case of sections the intervals and distances between sections are those resulting from the intervals and distances of the immediately preceding boat formation.

37. Any ponton may be designated as the guide, but unless specially designated the guide is always right.

38. **To embark.**—The company is marched to its drill ground, where it is divided into boat detachments of six men each. A suitable noncommissioned officer or well-instructed private is assigned to each detachment and acts as chief of ponton. Each chief of ponton marches his detachment to the place of storage of the oars and boat hooks and obtains the prescribed number of each. He then re-forms his detachment, as described in the School of the Boat, marches it to the ponton assigned to him by the company commander, embarks, but does not shove off, and awaits the commands of the flotilla commander. Lieutenants are assigned to pontons or are otherwise used as the captain may direct.

When practicable the pontons should be moored stern to the bank at intervals of about 20 yards.

39. When all the boats are in readiness the captain commands: SHOVE OFF, which is executed as prescribed in the School of the Boat. The captain then commands: 1. FORWARD! 2. MARCH! At the first command each chief of ponton commands LET FALL! and at the second command GIVE WAY! The captain embarks in his boat and follows up the movement. The chief of the guiding ponton directs his boat perpendicularly to the shore at a moderate speed. The other pontons preserve the intervals and the alignment. If the shore does not favor the formation of a long line of boats, they may be moored closer together and the flotilla may advance in column from the right or left, as hereafter described.

40. Having gained a sufficient distance from the shore, the captain drills the flotilla. Two formations are recognized—the line and the column. For convenience of reference all flotilla movements are classified in the following table:

FLOTILLA MOVEMENTS.

In line.	*In column.*
To halt.	To halt.
To dress	To advance.
To advance.	To back.
To back.	To oblique.
To oblique.	To change direction.
To turn.	To take distance.
To extend intervals.	To close distance.
To close intervals.	To form line to either flank.
To form column to front.	To form line to front.
To form column to either flank.	

To these should be added the anchorage and debarkation, either of which may be executed from line or from column.

41. **In line, to halt.**—Whether advancing or backing. The captain commands: 1. FLOTILLA! 2. HALT! At the first command the chiefs of pontons command: STAND BY TO LAY ON OARS! At the second command they command: OARS! HOLD WATER! followed by OARS! when the headway is checked.

42. **In line halted, to dress.**—The captain commands: 1. RIGHT (or LEFT) 2. DRESS! The first two pontons on the designated flank remain as steadily as possible in position, while the others place themselves on the line.

43. **In line, to advance.**—Whether at a halt or backing. The commands of the captain are: 1. FORWARD! 2. MARCH! They are executed as already described for embarking, omitting the command LET FALL, if not required. If backing, each chief commands: 1. OARS! 2. HOLD WATER! at the first command.

44. **In line, to back.**—Whether advancing or at a halt. The captain commands: 1. BACKWARD! 2. MARCH! At the first command, if advancing, each chief commands: 1. OARS! 2. HOLD WATER! if at a halt, he brings his crew to the position of OARS. At the second command he commands: STERN ALL! which is executed as prescribed in the School of the Boat.

45. **In line, to oblique.**—Whether advancing or backing. If the former, the captain commands: 1. RIGHT (or LEFT) OBLIQUE; 2. MARCH. At the first command each chief commands: OARS. At the second command he adds GIVE WAY LEFT (or RIGHT); BACK RIGHT (or LEFT). When the boat has changed its direction 45° he commands: GIVE WAY, and directs his boat so as to preserve his proper interval from the guide on a front parallel to the original alignment. To resume the direct march the captain commands: 1. FORWARD; 2. MARCH. The chiefs of pontons command: OARS, and GIVE WAY RIGHT (or LEFT); BACK LEFT (or RIGHT); and GIVE WAY as before. In backing similar commands are given, substituting BACKWARD for FORWARD, and STERN ALL for GIVE WAY.

46. **In line, to turn.**—Whether at a halt or advancing. The captain commands: 1. FLOTILLA; 2. RIGHT (or LEFT); 3. MARCH. At the first command the chief of the right ponton commands: 1. STAND BY TO LAY ON OARS. At the second command he commands: 2. OARS, and, if necessary: 3. HOLD WATER. He then turns his ponton to the right and holds water until the other pontons arrive on the line. The chiefs of the other pontons steer them by the shortest routes to their positions on the new line. As each interior ponton arrives on the line it is halted. When the last ponton is about to arrive on the line the captain commands either: 4. FLOTILLA; 5. HALT; or 4. FORWARD; 5. MARCH.

47. **In line, to extend intervals.**—Whether advancing, backing, or at a halt. The captain commands: 1. EXTEND ON PONTON NO. — TO — YARDS; 2. MARCH. If advancing or backing the chiefs o pontons command: OARS at the first command, and give the com

mands prescribed for obliquing toward the proper flank at the second, resuming successively the direct march as the intervals are gained. All boats except the designated one increase their speed until they arrive on the line.

If at a halt, the chiefs of pontons execute the movement prescribed for moving sideways in the School of the Boat, halting when the intervals are gained.

48. **In line, to close intervals.**—Whether advancing, backing, or at a halt. The captain commands: 1. CLOSE ON PONTON NO. — TO — YARDS; 2. MARCH. This movement is executed upon the same principles as the last, reducing the interval toward the indicated ponton.

49. **In line, to form column to the front.**—Whether advancing or at a halt. The captain commands: 1. RIGHT (or LEFT) BY PONTON; 2. MARCH. If advancing, the chief of the right ponton cautions his men to continue rowing slowly; the others give the command STAND BY TO LAY ON OARS. At the second command they add: OARS. As soon as the designated ponton has passed the next in line, the chief of the latter orders GIVE WAY and steers obliquely into position behind the first. The other pontons successively follow the movement so as to enter the column at their proper distance. If at a halt, the movement is executed on similar principles, the chiefs of pontons giving in succession the commands STAND BY TO GIVE WAY; GIVE WAY, so as to form the column as before. If the captain desires to form a column of sections he commands: 1. RIGHT (or LEFT) BY SECTIONS; 2. MARCH. The movement is executed upon the same principles as the foregoing, the boats of each section acting together under the commands of its chief.

50. **In line, to form column toward either flank.**—Whether advancing or at a halt. The captain commands: 1. PONTONS RIGHT (or LEFT); 2. MARCH; 3. FORWARD; 4. MARCH.

If advancing, each chief of ponton commands: RIGHT (or LEFT) STAND BY TO LAY ON OARS at the first command. At the second he commands: RIGHT (or LEFT) OARS; HOLD WATER. Followed at the proper time with the commands STAND BY TO GIVE WAY and GIVE WAY. If at a halt, the commands of the chiefs of pontons are: STAND BY TO GIVE WAY LEFT (or RIGHT), BACK RIGHT (or LEFT); GIVE WAY LEFT (or RIGHT), BACK RIGHT (or LEFT); STAND BY TO GIVE WAY; GIVE WAY. If the captain wishes to form a column of sections he gives the same commands, substituting SECTIONS for PONTON. Each section turns to the right by the commands and principles prescribed for turning by flotilla, substituting SECTION for FLOTILLA in the commands.

51. **In column, to halt, to advance, to back, and to oblique.**—The same commands and methods of execution are followed as in line.

52. **In column, to change direction.**—Given only when advancing. The captain commands: 1. COLUMN RIGHT (or LEFT); 2. MARCH. The chief of the leading ponton or section at once executes a turn to the right. Each boat or section executes the same movement upon arriving at the same point.

53. **In column, to take distance.**—Whether advancing or at a halt. The captain commands: 1. TAKE DISTANCE TO — YARDS; 2. MARCH. If at a halt, the chief of the leading boat or section commands: STAND BY TO GIVE WAY, and at the second command he commands GIVE WAY. These commands are repeated successively by the chiefs of pontons or sections in rear in time to secure the designated distances. If advancing, the chiefs of all pontons behind the leading boat or section command at the first command STAND BY TO LAY ON OARS. At the second command they command ARS, and resume the march successively as the designated distances gained.

4. **In column, to close distances.**—Whether advancing or at a halt. captain commands: 1. CLOSE TO—YARDS! 2. MARCH! The ment is executed by the same commands and principles as the the boat in front halting or remaining at a halt and those in moving up together and halting successively in position at the mands of their chiefs.

55. **In column to form line to either flank.**—Whether advancing or at a halt. The captain commands: 1. PONTONS (or SECTIONS) RIGHT (or LEFT)! 2. MARCH! 3. FORWARD! 4. MARCH! The movement is executed by the commands and principles prescribed for forming column from line.

56. **In column to form line to the front.**—When advancing or at a halt. The commands of the captain are: 1. RIGHT (or LEFT) FRONT INTO LINE! 2. MARCH! The leading ponton or section, by command of its chief, moves forward 20 yards to give the one following room to oblique into position, and then halts. The chiefs of the other pontons or sections give the commands prescribed for obliquing into line, move opposite to their positions, advance to the line, and halt, dressing upon the leading ponton or section.

57. **To anchor the flotilla.**—The flotilla may be anchored, whether in line or in column, whether at a halt or in motion, and whatever be the direction of the current; but, except in emergencies, the direction of motion should be up or down stream before giving the command. The commands of the captain are: 1. PREPARE TO CAST ANCHOR! 2. CAST ANCHOR! 3. BOAT OARS! The movements are executed as prescribed in the School of the Boat, the chiefs of pontons being careful to make fast their cables at such at length as to preserve their proper intervals and distances.

58. **To weigh anchor.**—The commands of the captain are: 1. ATTENTION! 2. PREPARE TO WEIGH ANCHOR! 3. FORWARD! 4 MARCH! At the second command each chief of ponton, after cautioning the two bow oarsmen to handle the cable, commands: UP OARS! At the third command he orders: LET FALL! and at the fourth command: GIVE WAY! The anchor is weighed as prescribed in the School of the Boat.

59. **To debark.**—This movement may be executed from line or from column. The captain, upon approaching the shore, makes the upstream ponton the guide, and commands: 1. PREPARE TO DEBARK AT — YARDS INTERVALS! 2. DEBARK! After the first command the guiding ponton is grounded and moored to the bank; the others, obliquing, if necessary, gain the indicated interval and execute the same movement. At the second command, which is not given until all the boats are secured, the chiefs of pontons file their men out, taking with them oars and boat hooks, unless otherwise instructed, and form their detachments facing their respective boats. The captain then gives such directions as may be necessary to re-form the company.

CHAPTER 4.

BRIDGES WITH THE BRIDGE EQUIPAGE.

SELECTION OF SITE.

1. The location of a bridge is usually fixed by tactical requirements but occasionally the advantages of a site may govern the movement of the troops. The orders for the construction of a bridge should prescribe only the limits within which the site may be chosen, leaving its exact location to be selected by the engineer officer in charge. He makes a reconnoissance of the reach prescribed in the orders and determines the site and method of construction, keeping in mind both the tactical and the technical requirements of a bridge site.

2. **Tactical requirements.**—In an advance the near shore should afford concealment for the operations preparatory to bridging and should command the farther shore. The latter should be open to allow of rapid deployment, and should not have near the bridge any high or difficult ground which the enemy might occupy. In a retreat high or difficult ground on the side from which the bridge starts i advantageous, as it enables the retreating force to hold on and t cover the bridge. The opposite shore should afford cover from hostil observation. If the bridge must be located in a bend, the passag should be toward the convex bank in an advance and toward the concave bank in a retreat. Concealment from possible artillery fire i always to be sought.

3. **Technical requirements.**—The bridge should be located in a straigh reach or gentle bend, where the bed affords good anchorage, slope gradually away from the bank, and is free from snags, bowlders, reefs or other obstructions; where the current is regular, parallel to th banks, and moderate; where the banks are firm and, if much abov the water, have easy slopes and are not rough, broken, or liable t overflow during ordinary rises. A bridge site meeting all these conditions will rarely be found, but as many of them as possible shoul be secured. The exit should be easier than the approach to avoi crowding on the bridge. A tributary stream may afford concealmen for the assembly of materials, in which case a site just below it mouth may be better than one elsewhere.

4. In addition to the foregoing the width of the stream, velocity of current, depth of stream, rise and fall of tides, variation i width of wetted section, and frequency and height of ordinary flood should be determined. Except for the measurement of width, onl rough data are required; the width should be determined fairl accurately.

5. A narrow stream may be measured by stretching a line acros it. The width of any stream may be determined with sufficien accuracy by the use of a prismatic compass or pocket sextant and base line measured by a tape or even careful pacing, utilizing th principles of similar triangles or of trigonometry. Velocities may b determined by the method of surface floats and depths by the use o sounding poles or lines. The rise and fall of tide are determine by observing the marks made by high tide and, if possible, by observing directly the water surface at both high and low tides. An allowance of a foot or more should be made for unusual tides. Th height of ordinary floods and variations in stream width may be determined by the location of drift and information from the in

habitants if no records of the stream are available. The frequency of rises must be learned from the inhabitants, from records, or from a general knowledge of the characteristics of streams in the same part of the country.

UNLOADING THE EQUIPAGE.

6. **The heavy equipage.**—A detail of 20 pontoniers is required for each ponton. The location of the bridge having been selected, the ponton wagons are brought as near the river bank as possible, with the rear of the wagons toward the stream. The pontons are unlashed and slid from the wagon beds directly into the water whenever possible. When a ponton can not be unloaded directly into the water, one end is slid from the wagon to the ground and the ponton then let carefully down by its unloading detachment; a barrel or roller is helpful in this operation. The ponton is then dragged or carried to the water and launched. Where the banks are too high to permit of launching the pontons directly into the water the boats can be skidded into the water on balks laid from the bank. As soon as the pontons are in the water the anchors are brought aboard, cables attached and coiled in the bows of the pontons, with the anchor on top with its flukes projecting over the gunwale. The pontons are then moored at convenient points along the bank. The trestles and other material are unloaded in convenient places near the work, their location depending upon the method of construction to be employed.

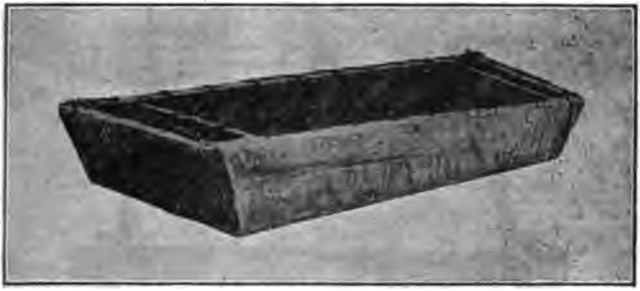


FIG. 36.—Method of folding ends of canvas cover on the light ponton.

7. **The light equipage.**—A minimum detail of eight men is required to unload and assemble each light ponton. A convenient locality is selected and the ponton wagons are brought up about 10 yards apart. The ponton frames and chests are then unloaded. To assemble each ponton the cover is spread on the ground and a side frame is laid on the outer strip of the cover with its bottom edge toward the center. The transoms are then inserted, the becket transoms being placed so that the beckets shall be toward the center of the ponton. The other side frame is then placed on the transoms. A lashing is passed through the rings of the side frames at each end, made fast, and twisted up with a rack stick. The frame is then turned over and centered on the canvas by means of the corner marks. The cover is then lashed on, care being taken that the canvas is brought up evenly all around the gunwale. At the end which is to be the bow the corner folds are turned back outside and along the sides of the boat to offer a smooth surface to the water, while for the same reason at the end that is to be the stern the corner folds are turned back outside and against the end of the ponton (fig. 36).

As each ponton is assembled, its detail carries it to the river and launches it. The canvas must not be allowed to rub or drag on any object nor to rest on any sharp point. If necessary to carry the boat any considerable distance, the men place the ponton on their shoulders. If the water at the bank is too shallow to float it, the men wade into the water before launching the ponton. As soon as each ponton is launched, it is moored, floored with 3 chess, and provided with 1 anchor and cable, 2 boat hooks, 18 lashings, 5 paddles, 1 pump, 8 rack sticks, and 2 scoops. The other material is unloaded in convenient places as near as practicable to the place where the bridge will be constructed.

CONSTRUCTION.

8. **The abutment bay.**—*Where the level of the water is not likely to vary sensibly* during the continuance of the bridge, two cases may arise:

First. When the water at a distance of one bay from the abutment is deep enough to float a ponton when loaded. The course here pursued is that hereafter described in the method by successive pontons (fig. 44), and is the one normally used for drill.

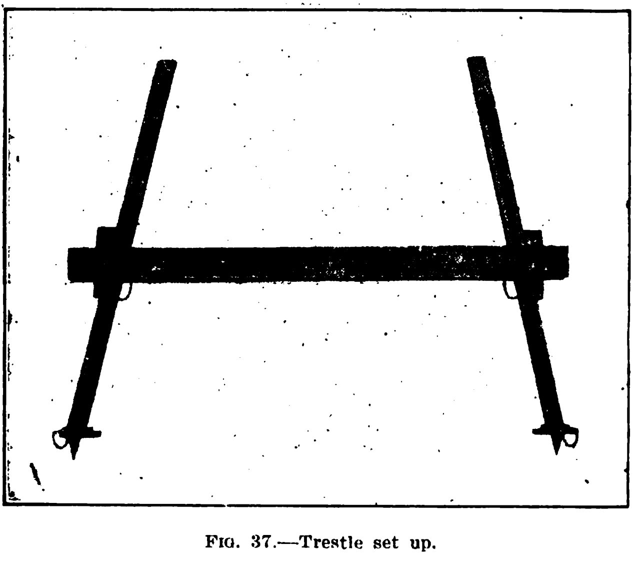


FIG. 37.—Trestle set up.

Second. When the water at a distance of one bay from the abutment is too shallow to float a ponton when loaded. In this case the first ponton is replaced by a trestle (fig. 37), which may be set up in place, may be placed as shown in figure 38 and described later under trestle bridges over a watercourse, or may be placed as follows (fig. 39): The abutment sill having been placed as described in paragraph 17, a ponton is brought up opposite it and two construction balks (long for heavy equipage, short for light equipage) are laid from its interior gunwale to the shore; a trestle cap is suspended from these by lashings and the claws of two trestle balks are engaged n the cap. The ponton is pushed off until the shore ends of the restle balk can be engaged on the abutment sill, or, in case of very hallow water, on the cap of a trestle previously laid from shore. he legs are inserted in the mortises of the cap, the shoes placed and eyed, and the legs driven down into the bed of the river. The pins nd wedges are then placed and the ponton and construction balks

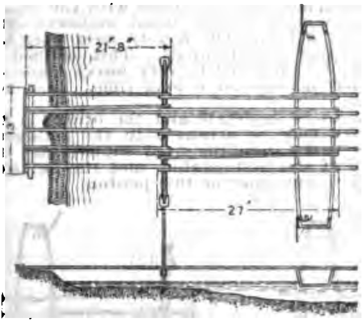


FIG. 38.—Abutment bay with trestle.

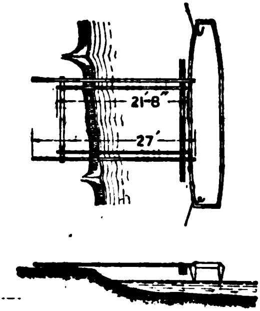


FIG. 39.—Method of placing trestle from a ponton.

removed. If it is desired to establish the flooring more than 2 feet above the water, the method indicated in figure 40 is preferable. The remainder of the construction proceeds in the usual way.

It is well to remark that all bays which are sustained by fixed supports at one or both of their extremities, should be reinforced by laying two extra balks (fig. 41), one between the first and second

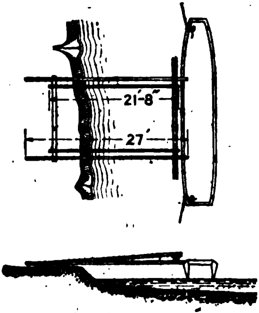


FIG. 40.—Method of raising floor more than 2 feet above the water.

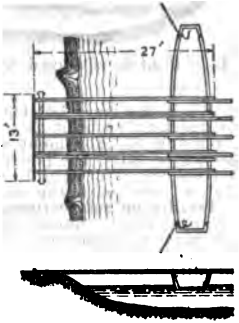


FIG. 41.—Method of laying two extra balks.

balks in contact with the second, the other between the fourth and fifth, in contact with the fourth—in order that they may have the same strength as those supported by pontons. This is necessary because the distance between the bearings is greater and the strain from a shock is more severe with fixed than with floating supports.

9. **The abutment bay.**—*Where the pontons rise and fall, as is the case in tidal streams,* the floor of the first bay is constantly changing

its inclination, while that of the remainder of the bridge contin horizontal. This hinging motion on the first ponton may be provid for in two ways:

First. By equipping the first ponton with a saddle (fig. 42). T saddle transoms are engaged on the gunwales of the ponton, 5 inch inside of the extreme lashing hooks; on these transoms is placed sill resting in the recess formed by their cleats. Seven trestle bal connect this sill with the fixed support and five balks with the seco ponton—where the lashings are made in the usual manner. Th side rails over the hinge should not lap, but merely meet over th saddle. The second bay may also be reinforced. This method i employed when the bridge is to be subjected to very heavy loads, o when it is to be used as a thoroughfare for a long time. It is n applicable to the light equipage.

Second. When the loads are to be moderate and the bridge is fo temporary use, the hinging bay may be arranged in the followin manner (fig. 43): The trestle balks from the fixed support are e gaged on the interior gunwale of the first ponton, and the balks o the second bay are lashed to both gunwales of this ponton.

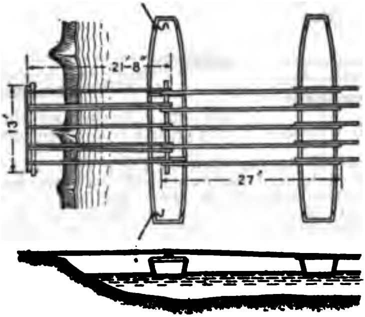


FIG. 42.—Ponton equipped with saddle.

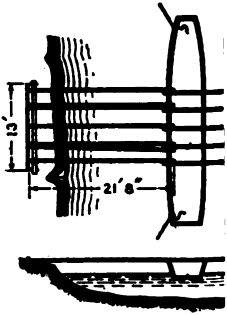


FIG. 43.—Second metho for hinging.

10. When the river bottom is of mud or sand and shoals graduall the bridge may be built as described in the article on successive pontons, placing the abutment sill about 2 feet above high-water mar As the water falls, the pontons ground successively, forming a gentl ramp from the abutment to the floating portion of the bridge. Thi can not be done with the light equipage.

11. **Trestles on soft bottoms.**—Where the bottom is soft or yielding trestles give much trouble from unequal settlement of the legs. Thi trouble may be somewhat remedied by lashing spars about 6 inche in diameter on each side of the legs, just above the shoes, to act a a mud sill.

12. **The bridge.**—There are four methods of constructing a ponto bridge, viz, by *successive pontons*, by *parts*, by *rafts*, and by *conversion.*

Although the varied circumstances under which military bridge are constructed in the field preclude the possibility of executing thi kind of work with the precision that should characterize other military movements, yet to insure the proper division of labor and promptness of execution, a routine drill for the instruction of enginee troops is necessary, the details of which should be as closely followed in actual service as circumstances will permit.

The method by successive pontons (fig. 44) is used as a drill unti the principles of construction are well understood, after which th pontoniers are instructed in the other methods for which no formal drill is prescribed.

BRIDGE BY SUCCESSIVE PONTONS.

13. **Personnel.**—A larger number of men than shown in the following table may sometimes be used to advantage in the construction of the bridge when great speed is required, the table showing only the normal number of pontoniers advisable for one division of equipage. When a company is assigned to instruction with the bridge equipage, the details from it will be regulated so as to provide for the drill as near the normal number as possible. Where the bridge exceeds one division in length, in order to keep up the same speed of construction as contemplated in this table, the number of anchor detachments, balk carriers, chess carriers, and side-rail carriers must be increased.

Name of section.	Noncommissioned officers.	Pontoniers.	Total.
Abutment	1	8	9
Upstream anchor	2	8	10
Downstream anchor	2	8	10
Balk carrier	1	10	11
Balk lasher	2	10	12
Cable	0	2	2
Chess	1	22	23
Side rail	1	8	9
Total	10	76	86

In constructing a ponton bridge, the anchorage and the lashings are the two points that require particular attention and the men intrusted with their execution should be selected from the most intelligent and experienced pontoniers in the command.

14. **Location of material** (fig. 45).—Those pontons destined to cast upstream anchors are moored above the entrance to the bridge; all the others below. The balks are piled on the left of the entrance to the bridge in the following manner: Two balks are laid on the ground parallel to each other and 18 feet apart; across these a layer of balks nearly in contact; then two chess directly above the first two balks; then another layer of balks, etc. The chess are piled on the right side of the bridge as follows: Three balks are laid on the ground parallel to each other and about 4 feet apart; on these a course of 10 chess, nearly in contact; across these 10 more chess at right angles to the first layer, etc.

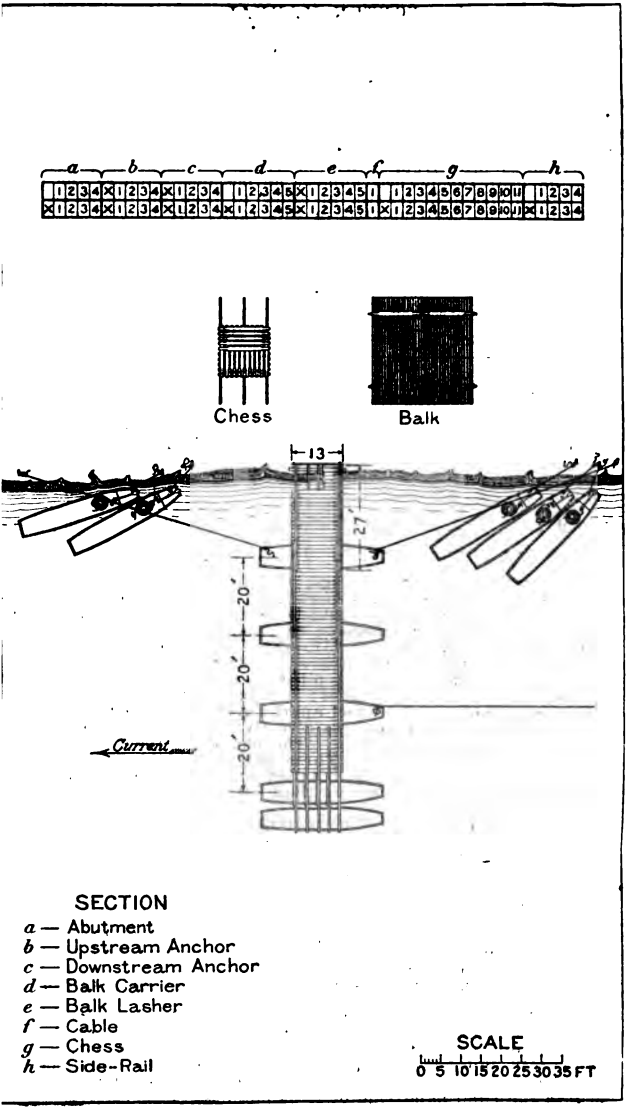
15. **Formation of sections.**—The material having been unloaded and all preparations made, the company is re-formed and the sections above prescribed selected. Each section is formed in two ranks, noncommissioned officers on the right (fig. 46). Where two noncommissioned officers are assigned to a section each has charge of one rank. The pontoniers are numbered from right to left in each section, the rear rank and front rank men to each file having the same number.

One lieutenant is assigned to the line of upstream anchors, and standing on shore supervises the casting of anchors and the movements of the upstream anchor section.

Another lieutenant supervises the location of the abutment and then takes his post at the head of the bridge.

The third lieutenant usually supervises the downstream anchors and keeps a watch over the movements of the sections at the piles of material to see that the material is promptly gotten out.

The captain supervises all the operations. Officers move about as required by their duties. In moving on and off the bridge men keep as close to the right-hand side of it as possible.



IG. 44.—Bridge by successive pontons. FIG. 45.—Location of material. FIG. 46.—Formation of sections.

16. The sections having been detailed, the captain commands CONSTRUCT THE BRIDGE, at which command all sections commence their duties and carry them out as prescribed below. It is intended that the one command of the captain shall cause every operation in the construction of the bridge by successive pontons to take place in its proper sequence, the noncommissioned officers in charge of sections keeping close watch upon the progress of the bridge and seeing that their sections are on hand at the instant they are required. The lieutenant at the head of the bridge keeps the sections moving promptly by calling their names, for example, CHESS, SIDE RAILS or BALK. It is important that no more noise than necessary be made in order that all may understand the commands given by the officers.

17. **The abutment section.**—The abutment section excavates a trench 1 foot deep by 1 foot wide to receive the abutment sill. The sill should be horizontal, exactly perpendicular to the axis proposed for the bridge, and firmly secured in place by four pickets driven two in front and two in rear, about 8 inches from each end. As soon as the balks of the first bay are in position a chess is placed against their ends, its upper edge on a level with the surface of the chess forming the roadway. It is secured by two pickets, and by packing earth in rear of it. The approach to the bridge is then prepared by cutting down the bank if necessary.

Having finished the first abutment, the abutment section, taking with it a sill, a chess, 8 pickets, 2 cables, and the necessary tools, is taken to the opposite bank by an anchor detachment, places the shore lines, and prepares the approach and abutment on the far shore, so that there will be no delay in the completion of the bridge.

18. **The anchor sections.**—Each anchor section is divided into two detachments consisting of a noncommissioned officer and four men. Each detachment embarks in a ponton as soon as the command is given to construct the bridge.

Each upstream anchor detachment moors its boat to the line of upstream anchors and above its place in the bridge. As soon as the position of the ponton has been verified the anchor is cast.

The first detachment then drops its ponton downstream without further command opposite the abutment and close to the shore, paying out the cable as the boat floats down to its place. The cable men enter the ponton, the cable is turned over to them, the anchor detachment comes ashore, embarks in another ponton and proceeds to the line of upstream anchors as before.

The first downstream anchor detachment casts an anchor in a manner similar to that prescribed for the upstream anchors, then pulls up to the bridgehead, hands over its cable and boat to the cable men, disembarks, and enters another downstream ponton.

The second upstream anchor detachment, as soon as its anchor is cast, drops its ponton down near its place in the bridge but clear of the latter. When the preceding downstream ponton is shoved off the second upstream ponton, without further command, drops down beside it. The cable men enter the upstream ponton, take its cable and hold the ponton to the downstream ponton. The crew of the upstream ponton then disembark, passing off by the right-hand side of the bridge as soon as the portion covered with chess is reached, proceed at once to another upstream ponton, and repeat the duties they have just performed.

The second downstream anchor detachment does not cast anchor, but pulls its ponton directly to its place in the bridge after the second upstream ponton has been shoved off and turns the ponton over to the cable men.

These operations are repeated in succession by the respective up and down stream anchor detachments.

19. **The cable men.**—At the command CONSTRUCT THE BRIDGE the cable men drive two pickets, one 30 paces above and one 30 paces below the axis of the bridge. To each of these a shore line is made fast, the free ends of which are carried by them into the bow and stern of the first ponton. The front-rank man attends to the bow and the rear-rank man to the stern lines. When the first ponton is pushed off it is brought into its exact position by means of these

lines. The officer in charge at the head of the bridge then commands: MAKE FAST! Both lines are drawn taut and made fast to the mooring posts by a mooring knot. The cable men then step into the second ponton, receive the anchor cables from the anchor detachment, bring the second ponton into place as soon as it is pushed off, and hold it so until the second bay is nearly covered. They then step into the third ponton, carrying the cables with them. When the third bay is nearly covered the upstream cable is made fast, but the downstream cable is carried to the fourth ponton, etc.

20. **The balk lashers.**—At the command CONSTRUCT THE BRIDGE the front rank of balk lashers proceed to the head of the bridge and enter the first ponton as soon as it drops into place. The noncommissioned officer takes a bundle of lashings from the locker in the stern and distributes them, two to each man. The men take their places opposite the lashing hooks, facing toward the shore, receive the ends of the balks presented to them by the balk carriers and engage the claws on the further gunwale, take one turn of the lashing around the end of the balk, and throw their weight on the latter as the boat is shoved off. As soon as the second ponton is brought to the head of the bridge the rear rank, placing their hands on one another's shoulders to steady themselves, walk along the balks already laid into the second ponton, where they take a position similar to the front rank. When the second set of balks is brought up they receive

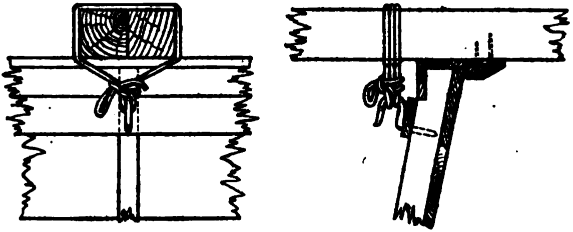


FIG. 47.—Balk lashing.

the ends from the balk carriers, lay them in place, and hold them as described above, when the boat is shoved off. In the meanwhile the front rank adjust the balks and lash them firmly, as shown in figure 47, to both gunwales of the first ponton. The front rank then pass into the third ponton. These movements are repeated in sequence until the bridge is finished.

The balks of the odd-numbered bays are laid as upstream balks that is, the downstream faces are placed to coincide with the marks on the abutment sill directly over the lashing hooks. The balks of all even-numbered bays are laid as downstream balks.

21. **The balk carriers.**—At the command CONSTRUCT THE BRIDGE the balk carriers place five balks on the ground parallel to the axis of the bridge and 2 feet apart, take their places, the front rank opposite the front ends and rear rank opposite rear ends of the balks. As soon as the noncommissioned officer sees the first ponton about to reach its position he commands LAY HOLD! RAISE SHOULDER! FORWARD! MARCH! Each file raises a balk, the front rank to the right the rear rank to the left shoulder, and the ection moves in line to the head of the bridge, where the noncommissioned officer commands HALT! LOWER! At the last command the front rank pass the front ends of the balks to the lashers in the ponton and, stepping back, assist the rear rank with the rear ends of the balks. As soon as the lashers have secured the balks to the ponton the chief of section commands SHOVE OFF! The balk carriers push steadily against their ends of the balks until the ponton is in position and then turn over the balks to the lashers. They are then marched off by the left flank and, proceeding to the

pile of balks, lay out five more balks, which they carry to the bridge as soon as called for in the manner just prescribed.

22. **The chess section.**—At the command: CONSTRUCT THE BRIDGE, the noncommissioned officer marches his section to the pile of chess and designates two men to act as chess layers. When the balks of the first bay are secured, the noncommissioned officer forms his section in column of files, the chess layers in front without chess. Each of the others carries a chess under his right arm, the forward end well up. They proceed to the head of the bridge, deliver the chess to the chess layers then return to the pile of chess. The chess layers stand on the balks to be covered (one on the first and second, the other on the fourth and fifth balks), facing toward the shore; they receive the chess from the carriers and place them, shoving each one hard against the preceding one, keeping the score marks in a continuous line on the axis of the bridge. The chess are laid to within 1 foot of the ponton. After the chess carriers return to the pile of chess each man, at the proper time, takes another chess and the noncommissioned officer forms his section in column of files near the abutment in readiness to pass on to the bridge at command.

23. **The side-rail section.**—At the command: CONSTRUCT THE BRIDGE, the noncommissioned officer forms his section and lays out two balks for the side rails of the first bay.

As soon as a bay has been completely covered with chess the side rails are laid and lashed. They are placed immediately over the outer balks and are secured by passing a lashing, twice if doubled and three times if single, round the balk and side rail, tying it loosely in a half bowknot (fig. 48), and then twisting it tightly with a rack stick. There are three lashings on each rail, one at the middle, the others over the axis of each ponton embracing two balks and two side rails. The lashings over the pontons on each bay are not made until the side rails for the next bay have been laid. The rack sticks incline toward the far shore on the right side and toward the near shore on the left side of the bridge. The side-rail lashers move from bay to bay, taking the lashings from the pontons and waiting in the latter until the side rails for the next bay are laid, when they proceed to make the lashings as above described.

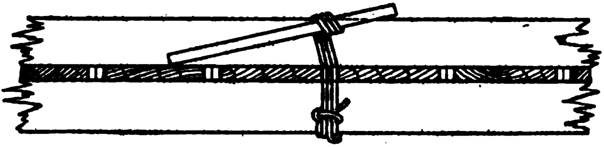


FIG. 48.—Rail lashing.

24. **Anchorages.**—The distance of the anchor from the bridge should be 10 times the depth of the stream if practicable; with a less distance the bow of the ponton might be submerged in swift current. The direction of the cable when made fast to the bridge should coincide with that of the current. Before turning the cable over to the cable men the chiefs of the anchor detachments make sure that the anchors have a firm hold on the bottom. When necessary the anchors should be recast. A cable is not finally made fast to the same ponton from which its anchor was cast, but to a ponton following it in the bridge, and due allowance must be made for this when casting the anchor. It is generally sufficient to cast an anchor upstream for every alternate ponton, and half that number downstream, but where the current is very rapid it may be necessary to anchor every boat upstream, especially near the middle of the bridge. The normal number of anchors can not be much diminished, however moderate the current, as the anchorage has a very marked effect in checking the horizontal oscillation to which floating bridges are subject when troops are marching over them; for this reason it is frequently advisable to in-

crease the number of downstream anchors. A downstream cable is never attached to a ponton that is not also anchored upstream.

25. **Sequence of events.**—The sequence of events is as follows, starting with the command, CONSTRUCT THE BRIDGE:

All officers and sections proceed to their posts and take up their respective duties.

The first ponton is moved into place and its crew comes ashore and goes for another ponton. The cable men and the front rank of balk lashers enter. The balks are then passed to the lashers in the first ponton and temporarily secured by them; the first ponton is shoved off, its position is adjusted and the cables made fast by the cable men under the direction of the lieutenant at the head of the bridge. The chess are then laid. While the first ponton is being placed the second ponton (first downstream ponton) is brought alongside, and the second rank of balk lashers and the cable men enter it, the cable men carrying the cable of the first anchor cast. The cable men take the cable of the second ponton and hold that ponton to the first by a quickly removable lashing. The crew of the second ponton passes ashore and goes for another ponton.

As soon as the last chess is placed the balks for the second bay are brought up, passed to the balk lashers, and the second ponton is shoved off, aligned, and made fast as prescribed for the first. The balk lashers in the first ponton make the permanent lashings and pass into the third ponton, which has been brought alongside the second.

As soon as any bay is completely covered, side rails are brought up, placed, and lashed.

When the officer at the end of the bridge commands or signals, "HALT," all detachments moving toward the head of the bridge halt in place, while those leaving continue and pass off the bridge. The construction is resumed by calling for the section desired.

26. **Dismantling by successive pontons.**—The material is supposed to be transferred to the shore opposite to that from which the bridge was constructed. The bridge is dismantled by successive pontons in the inverse order of the operations prescribed for the construction of the bridge.

BRIDGE BY PARTS.

27. **Method of construction** (fig. 49).—The abutment is constructed as in the previous method. The parts are constructed at suitable points along the shore above the bridge, and for each is required a detachment of not less than 12 men and the material for three bays. They are constructed as follows:

A ponton is moored bow and stern close to the shore and five chess are temporarily laid from the bank to its interior gunwale for the convenience of the pontoniers during the construction of the part.

The other two pontons are brought up in succession and two bays are constructed in the ordinary manner, except that seven chess are omitted from the roadway at each end. Twenty-seven chess and seven balks are loaded on the part thus formed, which is then pushed off and moved to the line of upstream anchors, where it casts at least one of its anchors and drops down to its place in the bridge.

The first part is connected with the abutment bay by the pontoniers on shore, who construct one length of bridge flooring in the usual manner to join the abutment bay with the first ponton of the part.

The other parts are united to the bridge as they come into position by bays formed from the balks and chess with which they are loaded. When the parts consist of an odd number of pontons the parts must be numbered successively. The odd-numbered parts lay upstream balks in the bay which will be nearest the abutment, while the even-numbered ones lay downstream balks in the corresponding bay.

The downstream anchors are cast from separate pontons provided for the purpose, and it may sometimes be necessary to cast the up

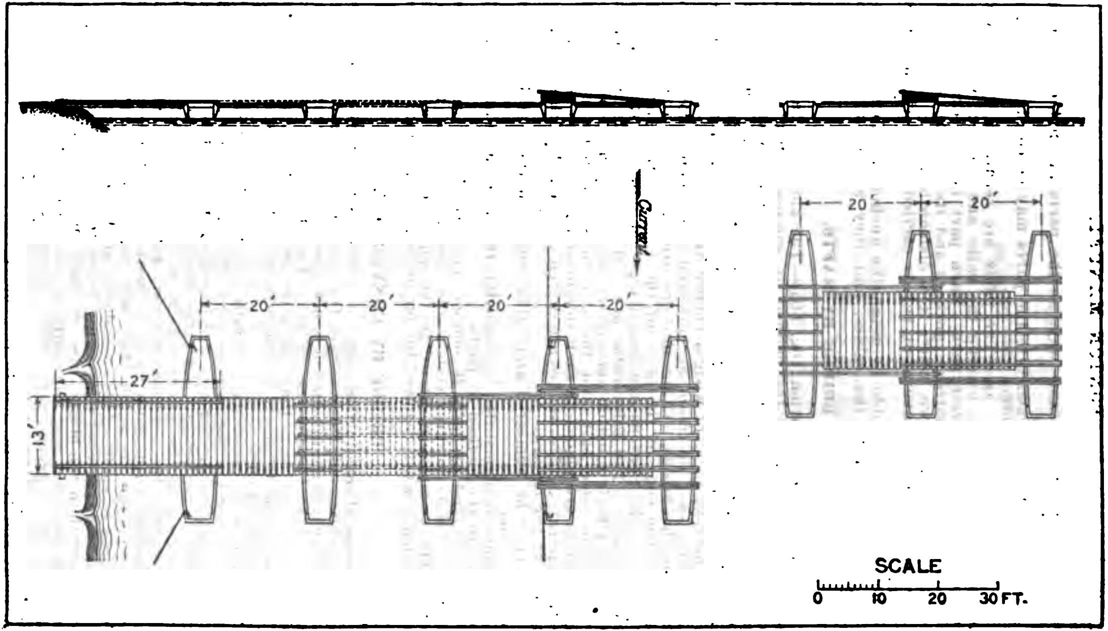


FIG. 49.—Method of constructing bridge by parts.

stream anchors in the same way, as the parts are not easily managed in a rapid current.

When the current is moderate the parts may be constructed below as well as above the bridge.

28. **Method of dismantling.**—The parts are separated by removing the connecting bays and loading the balks and chess of which they are formed on the nearest part. Each part is next drawn by its cables to the line of upstream anchors and its anchors weighed; it it then rowed to the shore, where it is dismantled.

The material of the abutment bay is carried off in the abutment ponton.

When it is impracticable to weigh the anchors as above described buoys are attached to the cables, and they are abandoned, to be picked up later.

BRIDGE BY RAFTS.

29. **Method of construction** (fig. 50).—The abutment bay is laid in the same manner as in the method by successive pontons, and the rafts differ from the parts only in having the roadway completed—that is, the seven chess at each end are not omitted. The rafts are not loaded with extra balks and chess, but are provided with two false balks 6 feet 9 inches by 5 inches by 5 inches, and with four rack collars and four pairs of wedges (figure 51).

The rafts cast upstream anchors and are dropped down to their places in the bridge. Other anchors are cast as in the preceding method. The ends of the balks of the adjacent rafts are placed in contact and the pontons are lashed together bow and stern by their mooring posts. The false balks are laid over the side rails of the two rafts at their junction and are secured by two rack collars, which embrace the false balk and the side rails and balks under them. These collars are placed on each side of and 2 feet from the junction of the side rails. The wedges are driven between the false balks and the tops of the collars.

Rafts must be numbered and balks laid upon them as in the preceding method.

The bridge is dismantled by removing the false balks and then proceeding as in the method by parts.

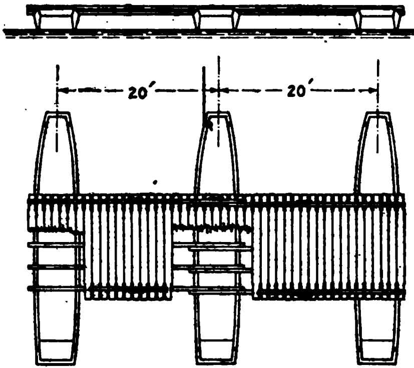
As the method by rafts is seldom employed, it has not been considered advisable to carry collars and false balks in the ponton divisions. The collars are carried in the supply division and the false balks are made when required by cutting a long balk into four pieces.

BRIDGE BY CONVERSION.

30. **Method of construction** (fig. 52).—The position of the bridge having been determined, the width of the stream is accurately measured and a suitable place at some distance above the abutment is selected for the construction of the bridge. This place may be at a considerable distance from that which the bridge is to occupy; it is frequently on some tributary of the stream to be bridged, out of sight of the enemy's shore.

The bridge is constructed parallel to the shore. Side rails are lashed on all except the extreme bays. The balks, chess, etc., for the abutment bay on the far side are placed on the next to the last upstream bay of the bridge. An extra ponton is lashed to the last upstream ponton in the bridge. This contains the articles necessary for constructing the abutment and two extra pickets. The upstream anchors are placed in the bows of the boats one or two boats upstream from the ponton to which they will finally be attached. Ten or fifteen yards of their cables are coiled and the remainder is stretched along the bridge toward the pivot. Two strong spring lines, considerably longer than the bridge, are stretched and fastened—one over the bows and the other over the sterns of all the pontons, with the ends coiled on the extreme bays. The bridge is then allowed to float down until the downstream ponton is within 15 yards of the near abutment and is made fast to the shore.

The material for the near abutment and bay is brought down in a ponton. Two pickets or other holdfasts are prepared for the spring



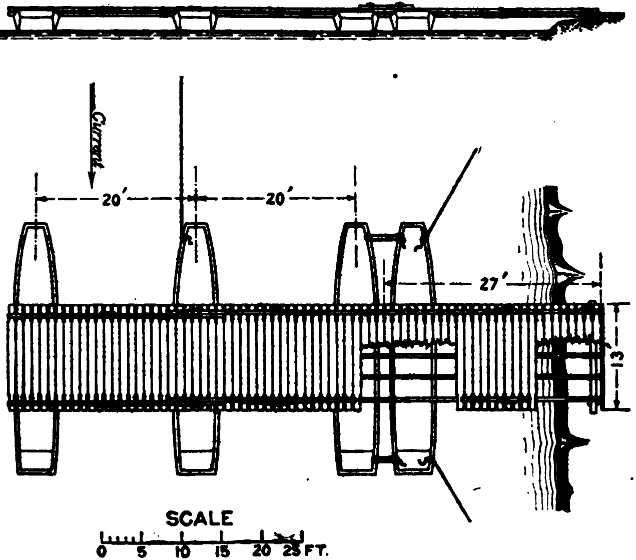


FIG. 50.—Method of constructing bridge by rafts. FIG. 51.—Method of constructing by two false balks.

lines, and two for the shore lines; which have been coiled on the roadway between the first and second pontons. The near upstream spring and shore lines are then made fast and the near abutment completed.

The upstream end of the bridge is then shoved off, and men are stationed in the bow and stern of each ponton with oars and boat hooks to increase or retard the progress of the bridge as may be necessary. One detachment is stationed at the near abutment to handle the spring lines; another to prevent the pivot end from touching the shore. A turn of the shore line is also taken around the mooring post of the pivot ponton, and this line is eased off as necessary. The anchors are cast as the pontons in which they are carried pass the proper places, and their cables are shifted to the pontons to which they are to be attached. The progress of the bridge is checked just above the line of the abutments and it is slowly eased down to its final position. The downstream anchors are cast from separate pontons, as in the bridge by parts. The far abutment is then constructed and the shore bays are laid.

31. **Method of dismantling.**—This maneuver is rarely executed, except by an army in retreat, closely followed by the enemy.

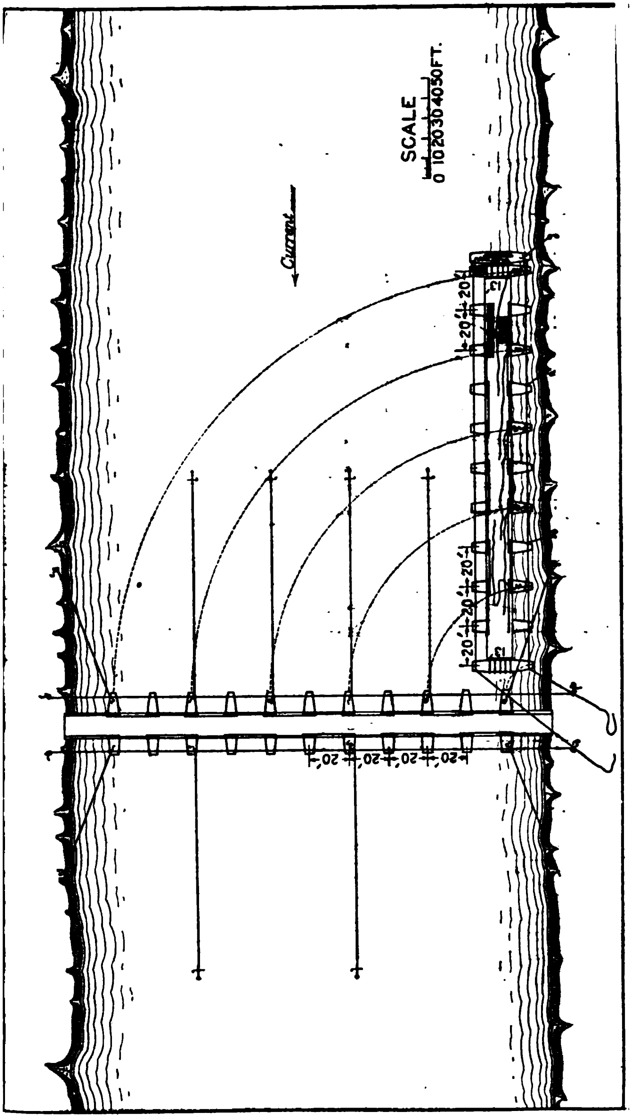
The shore bays are dismantled; the spring lines are left fastened; buoys are attached to the downstream anchor cables, which are cast off; the upstream anchor cables are lengthened out with spare rope; a strong line is passed from the next to the outer ponton to the shore toward which the bridge is to swing. The bridge is allowed to swing around, the upstream anchor cables and upper spring line being eased off. When the swing has been about half-completed, the pontons form such an angle with the current that the bridge no longer tends to move in an arc. The tendency then is to move obliquely downstream; the strain on the lower spring line than becomes very great, and the pontoniers must haul in on the shore line and use their oars and boat hooks. The upstream anchor cables are buoyed and cast loose if necessary. After the swing has been effected the bridge is floated downstream to some sheltered place and there dismantled.

32. **Comparison of the four methods.**—The method of construction by *successive pontons* possesses the advantages over the others of being applicable to all streams whatever may be their velocity, and of requiring the minimum quantity of equipage, the fewest pontoniers, and the shortest time for its construction. However, the labor of constructing a bridge by this method increases rapidly with the number of bays. Thus the balk and chess carriers in constructing a bridge of 40 bays are obliged to walk 6¾ miles; in one of 50 bays nearly 10¾ miles; of 60 bays 14¾ miles; and of 100 bays 40 miles.

The *method by parts* ordinarily is used in connection with the method by succesive pontons. When the bridge is to be more than 40 bays in length these methods are combined as follows: The bridge is begun at both ends if possible by successive pontons and is pushed on rapidly toward the middle of the stream. The two portions thus formed are connected by parts which are constructed in the meanwhile along the river bank above the bridge.

The *method by rafts* is employed when the passage of a river is to be forced, and when the rafts can be constructed unobserved by the enemy, in which case the pontoniers will be exposed to fire but a short time; that is, while the rafts are floating into position and being connected. In order that this method of construction should be successful, the current must be moderate, and there must be at a reasonable distance above the bridge positions where the rafts can be constructed undisturbed by the enemy. Such positions would be afforded by islands or tributaries in our possession. This method is also employed when the bridge is liable to injury from floating bodies as the portion threatened can be readily disconnected, dropped out of the bridge, and restored to its place when the danger is past. It may be used by an army hard pressed in retreat, as the rafts on the enemy's side of the river may be disconnected and moved to a place of safety.

The *construction by conversion* is a still more difficult operation. To insure success the current must be moderate, the holding ground good, and the pontoniers skillful, intelligent, and cool. The awkward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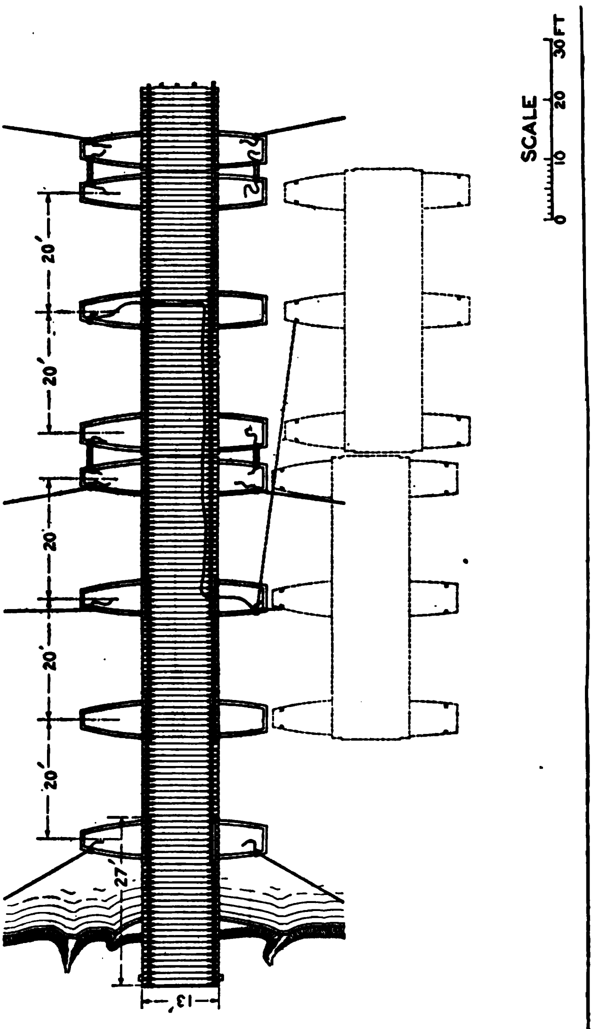

Fig. 58.—Drawbridge.

ness of a single man, the dragging of an anchor, or the parting of a cable may cause the failure of the entire operation. The opportunities for employing this method successfully will be exceedingly rare.

33. **Drawbridge** (fig. 53).—In navigable streams it is frequently necessary to provide a draw in the bridge; this is effected by introducing two or more rafts, constructed as described in paragraph 30, and located in the part of the bridge through which it is most convenient for vessels to pass. A swing line is attached, one end to the bow of the middle ponton of the draw and the other to the stern of the second ponton from the opening on the side toward which the raft is to be swung. To open the draw the raft is disconnected from the adjacent pontons and is allowed to drop out of the bridge by paying out the cable of its upstream anchor. When the swing line becomes taut the raft will swing into the required place as the anchor cable is further slackened, and it is then made fast by the swing line. The raft is replaced in the bridge by casting off the swing line and hauling in the cable of the upstream anchor. The draw may be also formed of two rafts, one dropping to the right and the other to the left of the opening.

34. **Bridge with extended intervals.**—This method is shown in figure 54. It has the advantage of increasing the normal length of a bridge with a given number of pontons by about 25 per cent, but it does not give the same strength or stiffness as the ordinary method. It answers, however, very well in small streams if the bays are reinforced by extra balks and even without this precaution when proper care is taken in passing the loads over the bridge.

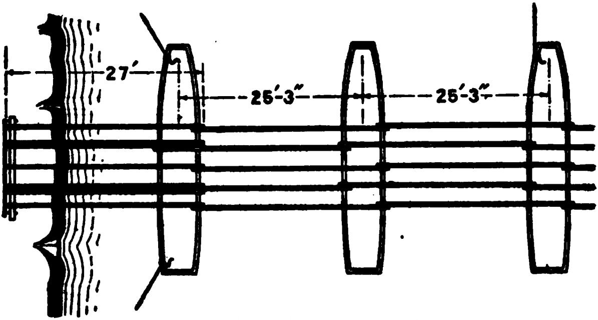

Fig. 54.—Bridge with extended intervals.

35. **Reloading the heavy pontons.**—In dismantling ponton bridges the balk and chess may be loaded directly on to the wagons or they may first be piled as described in paragraph 14 and loaded subsequently. For loading the boats the pontoniers are divided into sections of 1 noncommissioned officer and 20 men each. Seven balks having been placed on the wagon and secured by the dowels, the ponton may then be raised to its place by one of the following methods if the nature of the shore does not permit it to be floated upon the wagon backed into the water to receive it. In the first and third methods the front ends of the balks should first be fastened down.

36. *First* (fig. 55).—When two strong casks can be procured the ponton is placed in rear of the wagon with its stern toward and about 14 feet from the rear ends of the balks. The stern is raised sufficiently to allow the two casks to be placed under the ponton directly below the stern lashing rings, so that the chafing battens rest on the bilges of the casks. The pontoniers, who are stationed on each side of the ponton, seize it by the gunwales and push it forward toward the wagon, rolling it on the casks. As soon as the

stern rests on the side rails rack sticks are laid on the latter and the ponton is rolled into place.

Where casks are not available a special roller (fig. 56) may be used. This roller is held by two men and the ponton is pulled over it and on to the wagon as indicated above or by means of a cable looped about the mooring posts of the boat and leading directly up the axis of the wagon, the team being cut to one side. Care must be taken not to injure the ponton on the wagon standards.

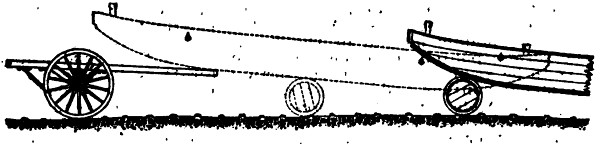

FIG. 55.—Reloading pontons by casks.

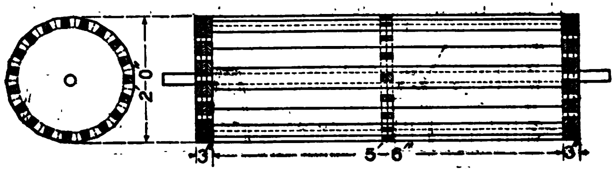

FIG. 56.—Special roller.

37. *Second* (fig. 57).—The wagon is unlimbered and the front part lowered to the ground; in this position the balks form an inclined plane, up which the ponton can be slid into place. The wagon is then limbered up. To facilitate the latter operation the ponton should be slid about 5 feet beyond its proper position on the wagon. The load will then be nearly balanced over the rear axle, which will allow the front part to be easily raised.

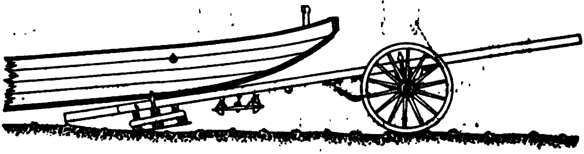

FIG. 57.—Reloading pontons by unlimbering.

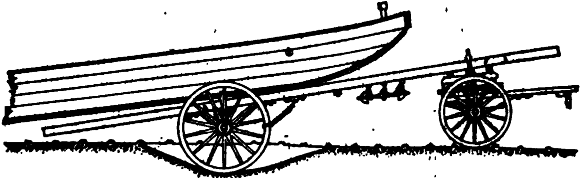

FIG. 58.—Reloading pontons by lowering rear wheels.

38. *Third* (fig. 58).—Holes about 18 inches in depth are dug in the ground to receive the rear wheels of the wagon; when the wheels

are thus lowered the rear ends of the balks will rest on or near the ground, and on the inclined plane thus formed the ponton is slid into place.

39. ***Fourth*** (fig. 59).—The ponton is placed 20 feet from the wagon and parallel to the position it is to have when loaded. A chess is laid on the side rail of the wagon nearest to the ponton. Three balks are placed so that one end of each shall rest on the ground, touching the ponton, and so that points 5 feet from the other end shall rest on the chess above mentioned. The balks are perpendicular to the side rail; the first rests on it over the forward wheel, the third in front of and in contact with the hind wheel, and the second half way between the two. The ponton is slid up the ramp thus formed until it touches the hind wheel, when the lower ends of the balks are raised until the ponton can clear the wheel; it is then pushed into place and the chess and three balks removed.

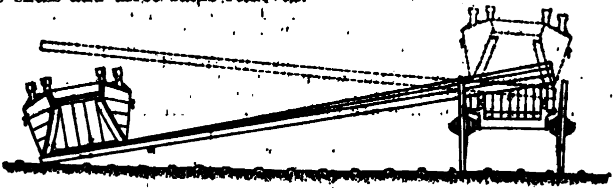

FIG. 59.—Reloading pontons by the side.

40. **Reloading the light pontons.**—A suitable detail is provided for each ponton. The ponton is brought up to the bank and the chess and other articles are removed. The ponton is then carried on shore, the men taking hold in pairs as it leaves the water. If there be much water in the ponton, it is advisable to unlash the cover at the river end to permit the water to run out as the boat is lifted. The cover is then removed and the frames taken apart for loading on the wagon. The wet cover is folded and lashed on top of the chest until the first opportunity occurs for drying it, when it is dried, refolded, and placed in the chest. Wet covers should not be stored in the chests.

41. **Loading other material.**—Suitable details are made for loading the other material. The loading is shown in figures 23 to 28 and 31 to 35 and described in paragraphs 19 to 22 and 37 to 39, chapter 2.

42. **Trestle bridges.**—They are of two descriptions; First, those built on the land; second, those built over a watercourse. Under the first head are included bridges built over dry ravines, over marshes, and over streams which are too shallow to float a ponton, but in which the pontoniers can wade when placing the trestles. Such bridges are constructed in the following manner:

43. **Trestle bridge on land** (fig. 60).—The abutment sill is placed as in ponton bridges and cords 20 feet long are stretched horizontally from the ends of the sill in a direction parallel to the axis of the bridge. The ends of these cords will indicate the position of the cap of the first trestle, and from their height above the ground may be estimated the distance which the legs are to be thrust through the cap.

The members of one trestle are brought up and assembled in a horizontal position with the cap toward the abutment and the points of the legs over the places they are to occupy. The trestle is then raised into a vertical position, and the exterior balks of the abutment bay are placed.

If the cap is now found to be out of the proper level, the correct position should be marked on the legs with chalk, the trestle lowered to the ground, the correction made, and the trestle again raised; the five remaining balks are then placed. The remaining trestles are placed in a similar way, and the flooring is laid as in ponton bridges.

44. Trestle bridge over a watercourse (fig. 61).—The abutment sill is laid in the usual manner, and a raft is constructed of two pontons connected by two balks lashed to the outer lashing hooks. The raft is partially decked by laying chess between and parallel to the balks, thus covering the first ponton and part of the second. On this raft the members of the trestles are placed, the caps and legs on the balks and over the second ponton, and the wedges and shoes in the bow and stern of the first ponton. The raft is brought opposite to the abutment, and is, at the commencement of the operation, held in position by the cable men with their shore lines; afterwards by cables from up and down stream anchors.

A trestle (fig. 62) is assembled with its cap resting on the ends of the balks which overhang the first ponton of the raft, its legs horizontal and pointing toward the abutment. The trestle being righted and the balks engaged on its cap, the raft is pushed off and the balks are engaged on the abutment sill. The position of the trestle is accurately adjusted by the cable men (fig. 63) and the legs are thrust down and driven with a maul into the bed of the stream. To allow for the tendency of the legs to spread apart when driven into the ground, they should, when first touching bottom, make a less angle with the vertical than 11°. As soon as the legs are settled into place the pins and wedges are placed and the raft is disengaged. The remaining trestles are similarly placed, and the roadway is finished as usual. The trestle bridge depends for its stability upon the strength of the claws on the balks and upon the immovability of the abutment sill; the importance of picketing the latter strongly will therefore be apparent. Though the trestle is in every respect inferior to the ponton bridge, yet the facility with which trestles may be constructed on the spot, whenever the requisite lumber can be obtained, renders this method very important. There are always an abundance of men in an engineer company who can construct rough trestles which will answer every purpose.

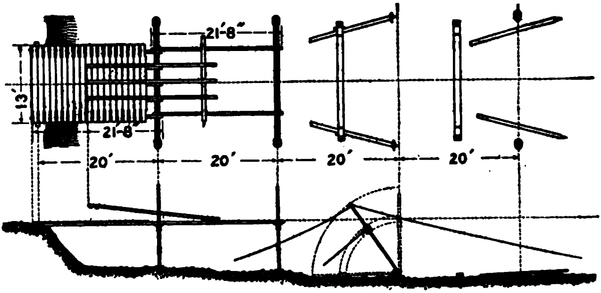

Fig. 60.—Trestle bridge on land.

The bridge is dismantled by bringing up the raft and reversing the operation just detailed.

45. Bracing trestle bridges.—To prevent a trestle bridge from collapsing, diagonals are sometimes inserted between the trestles. This may be done by driving poles in a slanting direction into the bottom of the river and then spiking them to the caps, or by spiking diagonals on the trestle legs. The continuous passage of troops in the same direction has a tendency to overthrow the trestles, particularly when the floor of the bridge is not level.

IMPROVISED FLOATING BRIDGES.

46. The same principles are applicable in this case as in that of ponton bridges, whether boats of commerce, timber rafts, barrel piers, or other supports are used.

Where boats of commerce are used the following additional precautions, however, must be observed:

As the boats are not usually of a uniform size, the length of the balks for each bay should be so proportioned to the capacity of the boat which sustains them that the bridge will not be endangered even when the bay is covered with as many men as can be crowded on it.

The boat next to each abutment must be strong and large.

Large boats should be selected for the strongest part of the current, so that they may be as much separated as possible. The bridge will then offer less obstruction to the current, and will also be in less danger from floating bodies.

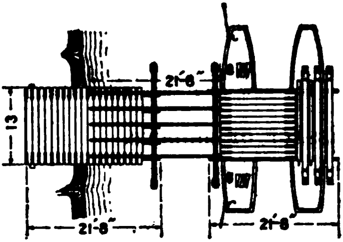

FIG. 61.—Trestle bridge over a water-course.

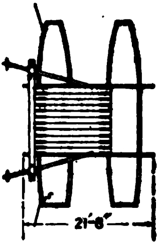

FIG. 62.—Trestle assembled.

The intermediate boats should increase or diminish in size gradually to avoid a sudden change in the level of the roadway.

The gunwales of the boats should be brought as nearly as possible to the same level. This is effected by cutting down the larger boats or loading them until they are sufficiently deep in the water; this latter expedient increases the strain on the cable and should not be resorted to in a strong current. In the smaller boats the gunwales must be raised, or a trestle, composed of a bottom and cap sill, united by stanchions of the proper length, is placed in the axis of the boat and kept vertical by braces.

The balks, when timber of sufficient dimensions can be procured, should be lashed over both gunwales of the two boats on which they rest. If the timber is not sufficiently long to admit of this arrangement, the following course is adopted: The balks of the first bay rest on both gunwales of the first boat; in the second bay the odd-numbered balks rest on both gunwales of the first and on one gunwale of the second and the even-numbered balks on one gunwale of the first and on both gunwales of the second; the odd-numbered of the third bay rest on both gunwales of the second and on one gunwale of the third boat, etc.

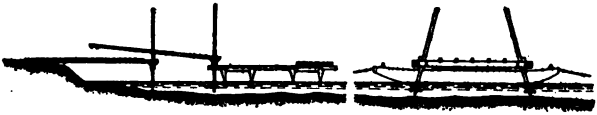

FIG. 63.—Trestle raised.

If a bridge thus made is subjected to the action of waves, the oscillating motion produced will soon loosen the balk lashings and destroy it and the use of saddles will be necessary.

IMPROVISED PILE DRIVER.

47. When an ordinary pile driver is not available one may be improvised from the material contained in the bridge train in the fo lowing manner (fig. 64): A raft is formed of two pontons covere with balks and chess; on the side rails are laid two balks *b b*, whic are secured to the pontons by bolts and lashings. Two balks *c c* a placed vertically, notched 2 inches deep, and bolted to the balks *b* They are stayed by the balks *d d* and the guys *r r* and by a cap The hammer *h* is a log of heavy wood, about 16 inches in diamet and 4 or 5 feet long, smoothed on two opposite sides to fit betwe the balks *c c*. Two pins are driven into the hammer on each sid near the top and bottom to serve as guides. A single block is attache to the cap by a ring bolt or rope; through this block a fall is passe provided with a hook at one end for the purpose of attaching it t the hammer. To the other end a number of balk lashings a attached, by means of which the hammer is raised by men on th raft. The raft is held in position by three anchors, the cables fro two of which are attached to the bow and that from the third t the stern of the raft.

AIDS TO PASSAGE OF BRIDGES.

48. **Ramps.**—Abutment bays and approaches should not be steepe than 1 : 7 for artillery nor than 1 : 10 for other wheeled transportatio Where the slope is steeper than 1 : 20, cleats should be nailed to th chess in wet weather to give the animals a footing.

49. **Cover for the roadway.**—The travel on a bridge soon wears out the chess, while the noise and slipperiness of the latter are alarming to animals. The chess should be covered, whenever possible, to prevent these troubles. Straw and weeds about 6 inches thick, earth not over 1½ inches thick, sand not over 1 inch thick, or other suitable covering, may be used between the side rails.

50. **Guard rope.**—Animals sometimes become confused and alarmed in pasing over running water, and may even leap off the bridge. To increase their confidence a guard rope may be stretched between stakes lashed to the side rails.

RULES FOR THE CARE OF BRIDGES.

51. An engineer officer, with a suitable detail of engineer troops is assigned to the charge of each bridge. This officer is responsibl for the safe and speedy passage of the command, and his orders an those given by the bridge guard, pursuant to his instructions, mus be strictly complied with by all persons crossing the bridge. (Par 103, F. S. R., 1914.)

When a body of troops approaches the bridge its commander is informed of any special provisions to be made for passage. Cavalr and other mounted troops cross in column of two, the men dismounte and leading their horses.

Officers and men individually mounted are warned to dismount an lead their mounts should the latter be restless.

Infantry cross in column of squads at route step. Artillery cros with intervals of at least one bay between carriages of light artiller and of at least two bays between carriages of heavy artillery.

Wagons and trucks cross with intervals of one or more bays, d pending on their loads. Wheels of vehicles must not be locked o the bridge. Vehicles that are too heavily loaded will be required t remove part of their loads before entering the bridge.

As soon as they have passed off the bridge troops and vehicles i crease the gait for a reasonable distance in order to clear the ex promptly.

In crossing cattle and loose animals, groups of from five to six on are admitted to the bridge at one time.

Columns of troops will not be allowed to pass each other on th bridge. When two columns approach the bridge from opposite dire

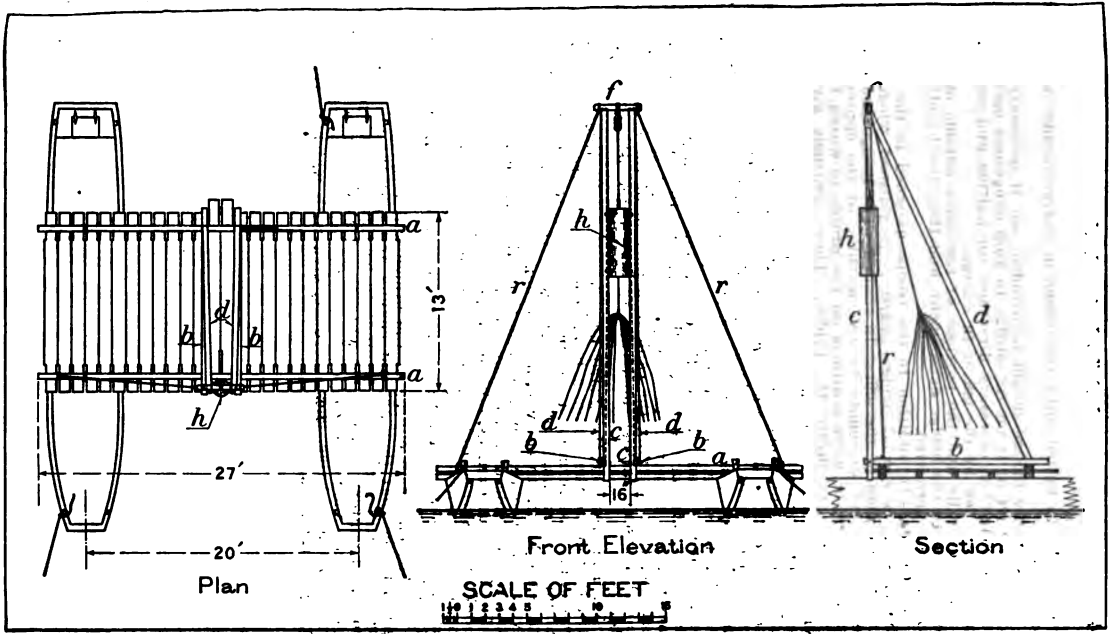

Fig. 64.—Improvised pile driver.

tions both are halted until the officer in charge decides which is to pass first.

Halts on the bridge should be avoided, but if necessary to halt a column or part of it on the bridge to stop dangerous oscillations or repair damage the necessary directions for halting and resuming the march are given by the officer in charge.

The side rails and the portions of the chess outside of them are for the use of the bridge detachment, and their use by other persons will not be permitted.

52. **Guards.**—In addition to the troops assigned to the defense of the crossing a special bridge guard is established when necessary under the orders of the officer in charge. The bridge guard posts a sentinel at each extremity to give warning of the approach of columns and one or more sentinels on the bridge to watch for floating objects liable to injure the bridge. These sentinels give warning when the bridge is in danger from any cause and see that the regulations for passage are complied with.

53. To prevent damage to the bridge from floating objects a detachment in boats is stationed at different points across the river about 1,000 yards above the bridge. The detachment is provided with cables, anchors, grapnels, hammers, etc., and should tow all dangerous material to shore above the bridge. If this can not be done, an anchor line is made fast to the object and the anchor so cast that the first strain on the cable will be oblique to the direction of the current; the body will then swing around and lose part of its momentum, thus relieving the cable of a portion of the strain. Patrols should be sent farther upstream to watch for dangerous floating objects.

54. The work of the guard may sometimes be lightened by constructing above the bridge a boom, composed of trees or logs, united by chains, and forming a continuous barrier to floating objects. It should form an angle of about 20° with the current, which will require the length to be two and three-quarters times the width of the river. As a boom is not a reliable protection, it should be established at a considerable distance above the bridge.

55. **Other precautions.**—Where much drift is expected the bridge should have several draws provided for the passage of floating bodies. In freezing weather the cables should be protected with cloth or marline or by wooden housings extending each way from the surface of the water.

56. The officer in charge of the bridge will frequently inspect the cables to see that they are not chafing and that the anchors do not drag. He will cause rack lashings to be tightened when they work loose and pontons to be bailed when they leak or ship water.

57. There should be collected near the entrance to the bridge a supply of spare balks, chess, cordage, etc., with which to repair any injury to the bridge.

CHAPTER 5.

TRANSPORTATION OF BRIDGE EQUIPAGE.

1. **Shipments by rail.**—Ponton equipage will preferably be shipped with all carriages fully loaded, tongues removed, front trucks, when practicable, turned 180°, and all the wagons pointing in the same direction. Any other method of loading will involve much loss of time, both at point of shipment and of delivery. End-opening gondola cars are preferable, but flat cars can be used. The 40-foot car is preferable for this purpose. Cars shorter than 36 feet are unsuitable. The following is the number of 40-foot cars required for shipment of the equipage as above indicated: To each division of light equipage, 7 cars; to each division of heavy equipage, 10 cars. If 36-foot cars have to be used the following numbers will be required: To each division of light equipage, 12 cars; to each division of heavy equipage, 13 cars.

2. Where mixed lengths of cars are used the number required for the heavy equipage may be determined from the following data: Each 40-foot car will carry one ponton wagon and one chess wagon, or one ponton wagon and one tool wagon, or one trestle wagon and one chess wagon, or one trestle wagon and one tool wagon, or two chess wagons or two tool wagons, or one chess wagon and one tool wagon. Each 36-foot car will carry one ponton wagon or one trestle wagon, or two chess wagons or two tool wagons, or one chess wagon and one tool wagon. A balk wagon takes the same space as a ponton or trestle wagon. With care three chess wagons can be loaded on a 40-foot car, but it should be done only in an emergency.

3. In loading a division of heavy equipage on 40-foot cars the following arrangement is preferable: One car, one tool wagon and one trestle wagon; four cars, one ponton wagon and one chess wagon each; four cars, one ponton wagon each; one car, one trestle wagon. Five of these cars may be 36-foot cars without affecting the loading. An army wagon or a company tool wagon may be placed on each 40-foot car carrying but one ponton or trestle wagon. The wagons should be loaded from one end of the train. To load a ponton and a chess wagon on the same car the chess wagon should be loaded first and the ponton wagon run forward until the stern of the ponton overhangs the chess.

In loading a division of heavy equipage on 36-foot cars the following arrangement is preferable: One car, one tool wagon and one chess wagon; two cars, one trestle wagon each; eight cars, one ponton wagon each; one car, two chess wagons; one car, one chess wagon.

4. When mixed lengths of cars are used the number required for the light equipage is determined from the following data: A 40-foot car will take any two carriages of the light equipage. If 36-foot cars are used, one car must be allowed for each ponton wagon. for each trestle wagon, and for each two of the other wagons.

5. In loading light equipage on 40-foot cars, the following arrangement is preferable: One car, one tool wagon and one trestle wagon; two cars, one ponton wagon and one chess wagon each; three cars, two ponton wagons each; one car, one trestle wagon. An army wagon or a company tool wagon may be placed on the car with the trestle wagon.

In loading light equipage on 36-foot cars the following arrangement is preferable: One car, one tool wagon and one chess wagon; two cars, one trestle wagon each; eight cars, one ponton wagon each;

one car, one chess wagon. An army wagon or a company tool wagon may be added to any car except the first.

6. **Entraining.**—The cars are run on a siding with one end at a crossing, if possible. All brake handles are then removed and, in case of end-opening gondolas, the end doors are let down to give a crossing between the cars and a clear passage for the wagons. Loading should take place from one end. Wooden crossings (fig. 65) are placed between flat cars, two to each gap, to permit the wagons to be rolled steadily forward. A ramp (fig. 66), composed of a loading trestle (fig. 67), a horse (fig. 68), and material of the equipage is built at the end of the train at which loading takes place. A snatch block is rigged at the far end of the car to which the ramp leads and a rope is run through the block. A loading hook (fig. 69) is fastened to the end leading directly down the ramp. A pair of mules in lead harness is hitched to the rope. As each wagon is brought to the end of the ramp its team is taken out and the loading hook on the rope is placed in the ring at the end of the tongue. Two men take hold of the tongue and guide the wagon while it is pulled aboard by the mules attached to the end of the rope.

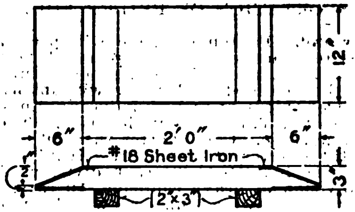

FIG. 65.—Wooden crossing.

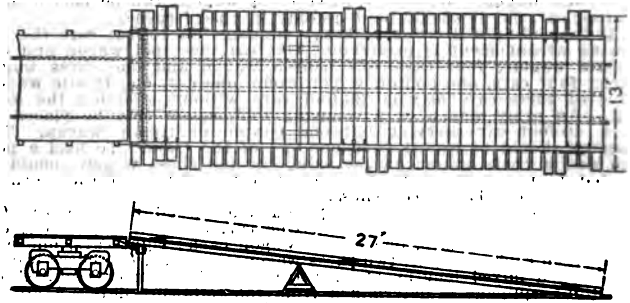

FIG. 66.—Ramp.

As soon as the wagon is aboard, the loading hook is released and a suitable detail runs the wagon by hand to its place on the train. The other wagons are brought up in turn and loaded in the same manner. An officer or noncommissioned officer sees that each wagon is properly placed on its car, tongue removed, front truck reversed when necessary, and brake set, and then sends the detail to bring up another wagon.

Blocking (fig. 70).—Each wagon is secured to the car by spiking a 3 by 4 inch scantling on the inside and outside of each wheel, and to these scantlings are spiked three cross scantlings, one in front, one in rear, and one through the wheel between the spokes. Each wagon to be loaded will require 48 linear feet of 3 by 4 inch scantling. As soon as a wagon is blocked it is lashed on with an anchor cable. The method of lashing a ponton wagon is shown in figure 71. An alternative method is to make the cable fast to a stanchion socket and reave it as follows: Rear lashing ring, midway stanchion socket, forward lashing ring, forward staunchion socket, pass to other side of car and reave in reverse order, coiling excess cable in the boat. All wagon brakes are set and tied fast with a lashing. Wagon tongues may be lashed to the wagons or placed in the boats. Car brakes are then replaced and, if gondolas are used, the end gates are raised.

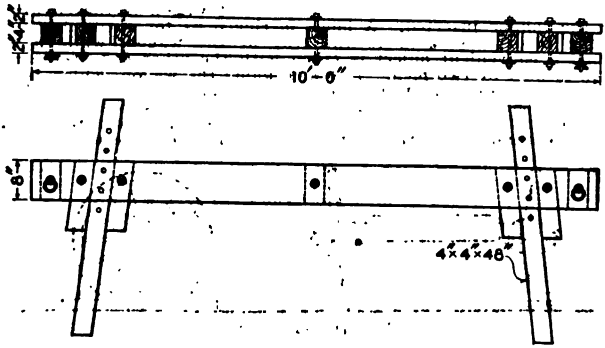

FIG. 67.—Trestle.

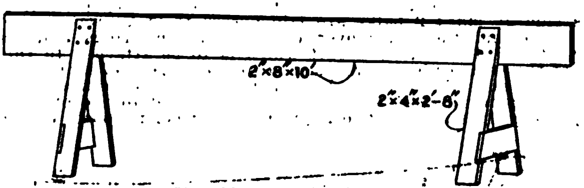

FIG. 68.—Wooden horse.

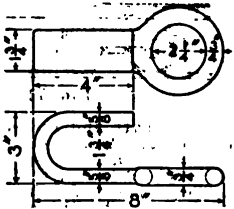

FIG. 69.—Loading hook.

7. **Loading animals.**—Animals are loaded in the usual manner, the officer in charge of the loading directing each team to proceed to the cars as soon as it is evident that it will not be required for further hauling. Where no loading platforms are available ramps may be built of the bridge material. A guard rope should be run on each side of the ramp.

8. **Care of equipage en route.**—An officer with a detail of troops, and the necessary animals to move the wagons should accompany each section or train carrying ponton equipage. Two men ride with the wagons, moving from car to car from time to time to see that the material rides well. When any of the material is seen to be in danger the conductor is notified. At stops all blocking and lashings are examined and, if necessary, are put in order.

9. **Detraining.**—Detraining takes place from one end of the train, preferably that opposite from the one at which entraining took place. The blocks and lashing are removed and a ramp is constructed if necessary. The brake handles are removed and crossings put in place between cars. The front truck of the first wagon is turned around and the tongue inserted. A block is rigged as for entraining. The loading hook is secured to the rear of the wagon, while a turn around a convenient object is taken with the other end of the rope, which is held by two men. Two men guide the wagon, which is then let down the ramp, the men on the rope slacking off slowly and steadily. As soon as the wagon is off the ramp its team should be attached and the wagon removed without delay. Other wagons are moved by hand to the ramp and unloaded in the same manner.

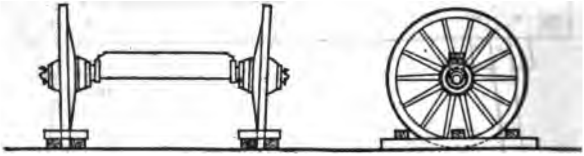

Fig. 70.—Blocking.

10. **Time.**—Where proper facilities are available a division of equipage can be loaded or unloaded in two hours.

11. **Shipments by water.**—It is sometimes desirable to move the ponton equipage by water. In such cases they may be rafted in the following manner: Each ponton is loaded with 20 chess and 7 balks, the latter uppermost. Rafts are then constructed by placing 4 pontons side by side; 2 balks are laid across their gunwales, one over the front and the other over the rear lashing rings and secured firmly to all 4 boats. The raft which is to be attached to the towline of the steamer has a balk lashed to and in rear of its low mooring posts; to this the towline is attached. The remaining rafts are brought up in succession; each raft is attached to the one in front by passing lines around two adjacent bow mooring posts of the two middle boats and the corresponding stern mooring posts of the raft preceding. As a precaution against the accidental parting of any of these lines a cable should be stretched along the axis of the entire raft and made fast to the steamer.

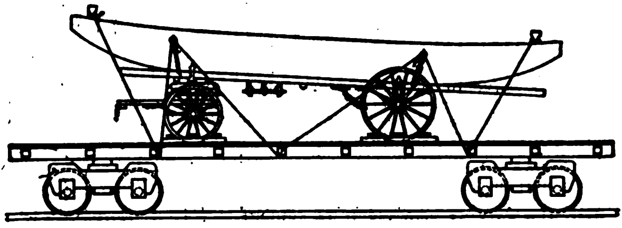

Fig. 71.—Lashing ponton wagon on car.

The number of rafts in a tow and the distance between them will be governed by the anticipated roughness of the water. In smooth water an ordinary tug will conveniently draw 40 pontons.

Each raft should always have a crew of four men provided with oars for steering, and with spare lashings for repairing damages.

When it is required to transport carriages they may be taken apart and packed into the pontons; but if the water is comparatively smooth the following is a better method: Rafts are formed of two pontons covered with a platform, thus presenting the appearance of one bay of a bridge. This platform, which is 27 by 18 feet, will carry four ordinary wagons, or four ponton wagons if they are unlimbered.

These methods of moving the ponton trains were used repeatedly in the campaigns of the Army of the Potomac, and were found to be more safe and expeditious than transportation in lighters.

12. **Over-sea transportation.**—When equipage is to be moved over-sea the loads are removed from the carriages and the latter are taken apart for shipment. In loading the following general rules should be observed: Each wagon, its load, animals, harness, and driver, will all be on the same vessel. When practicable, pontons will be stored where they can be readily gotten at for calking en route and for use in landing. Harness for each team will be packed in sacks and plainly marked for identification.

If the landing takes place at a wharf, each wagon will be set up, loaded, and driven off as soon as possible to clear the wharf. If the landing be by lighters, rafts may be made of the boats and used as lighters. Animals may be swum ashore or, if the water be calm, may be taken aboard the rafts.

13. **Unloading transports.**—In quiet water pontons floored with chess may be used for landing supplies from ships. Six tons may be carried at a trip in smooth water. Field guns and, if necessary, siege guns may be landed in still water by the use of rafts. In quiet water, a landing stage, consisting of a short section of bridge, may be built for convenience in unloading.

14. **Instruction of drivers.**—Drivers for the ponton equipage should be given instructions from time to time with a view to insuring proficiency in handling wagons and teams on the march and in restricted positions. For the purpose, pontons of the equipage should frequently be taken over difficult roads and ground, and should also be caused to execute simple movements, following the general principles and methods prescribed for field artillery.

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[C. P. M. 1]

PONTON MANUAL.

CHANGES No. 1. } WAR DEPARTMENT,
WASHINGTON, *June 14, 1917.*

Paragraphs 2, 7, and 25, chapter 2, Ponton Manual, United States Army, are changed as follows:

Add the following footnote to paragraph 2, chapter 2, at bottom of page 32:

* Tables of Organization, 1917, assign to the Engineer train of each Infantry division two ponton divisions and 1/3 supply division, except pile driver and spare ponton tool wagon. The two latter will be assigned to advance depots in proportion of 1 to each 3 Infantry divisions supplied. (*C. P. M., No. 1, June 15, 1917.*)

[2619756, A. G. O.]

Par. 7, Chap. 2. On page 34, add to the list under "Miscellaneous Supplies" the following:

8	king bolts.
100	cotters, assorted sizes.
10	dowers for balk, complete with bolt and nuts.
15	open links.
22	linchpins.
22	linchpin washers.

(*C. P. M., No. 1, June 15, 1917.*)

[2619756, A. G. O.]

Add the following footnote to paragraph 25, chapter 2, at the bottom of page 43:

* Tables of Organization, 1917, contemplate that one complete train of light equipment shall constitute the ponton section of the Engineer train of each Cavalry division. (*C. P. M., No. 1, June 15, 1917.*)

[2619756, A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

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